The Journal of Bone and Joint Surgery*

The Official Publication of the American Orthopaedic Association and of the British Orthopaedic Association

* Title registered in United States Patent Office

VOL. XIV, No. 3 *July, 1932* **Old Series VOL. XXX, No. 3**

Editor, E. G. BRACKETT, M.D. *Assistant Editor*, FLORENCE L. DALAND
British Editorial Secretary, GEORGE PERKINS, M.Ch., F.R.C.S., 102, Harley St., London, W. 1.

EDITORIAL COMMITTEE

Officers of the American Association

JOHN L. PORTER, M.D., *Treasurer*, 636 Church Street, Evanston, Illinois
DEFOREST P. WILLARD, M.D., *Secretary*, 1916 Spruce Street, Philadelphia, Pennsylvania
MELVIN S. HENDERSON, M.D., *President-Elect*, Rochester, Minnesota

Representing the British Association

E. P. BROCKMAN, F.R.C.S., *Secretary*, 73, Harley Street, London, W. 1.

Published Quarterly: January, April, July, and October
8 THE FENWAY, BOSTON, MASSACHUSETTS

¶ ORIGINAL ARTICLES. — Papers for publication will be accepted only for exclusive publication in this Journal. The American Orthopaedic Association and the British Orthopaedic Association do not officially endorse the opinions presented in the different papers published in this Journal. ¶ ADVERTISEMENTS. — Advertising rates will be furnished on application. ¶ CHANGE OF ADDRESS. — In sending change of address, both the old and new addresses should be given. ¶ THE SUBSCRIPTION PRICE of this Journal is $5.00 per year, payable in advance, for the United States and such other countries as, under the revised postal regulations, are subject to domestic rates; $5.25 for Canada; the equivalent of $5.50 for all other foreign countries included in the postal union. Single copies of current issue $1.50. ¶ Checks, drafts, and post-office money-orders should be made payable to The Journal of Bone and Joint Surgery.

Address all Communications to the Editor

THE JOURNAL OF BONE AND JOINT SURGERY

8 The Fenway, Boston, Massachusetts, U. S. A.

TABLE OF CONTENTS

PAGE

THE CORRELATION OF EXPERIMENTAL STREPTOCOCCIC ARTHRITIS IN RABBITS WITH CHRONIC RHEUMATOID ARTHRITIS. *By L. G. Hadjopoulos, M.D.*, and *Reginald Burbank, M.D.*, New York, N. Y. 471

PATHOLOGICAL FRACTURES IN OSTEOMYELITIS. *By Norman Capener, F.R.C.S.*, Exeter, England and *Kenneth C. Pierce, M.D.*, Ann Arbor, Michigan 501

SPONDYLOLISTHESIS AND VERTEBRAL ANOMALIES IN SKELETONS OF AMERICAN ABORIGINES. WITH CLINICAL NOTES ON SPONDYLOLISTHESIS. *By Russell T. Congdon, M.D.*, Wenatchee, Wash. 511

OPERATIVE FUSION OF THE UNSTABLE OR FLAIL KNEE DUE TO ANTERIOR POLIOMYELITIS. A STUDY OF THE LATE RESULTS. *By Mather Cleveland, M.D.*, New York, N. Y. 525

OSTEOCHONDRITIS DISSECANS. A CLINICAL STUDY OF TWENTY-FOUR CASES. *By Don King, M.D.*, Ann Arbor, Mich. 535

KYPHOSIS ADOLESCENTIUM. *By Prof. Bedrich Frejka*, Brno, Czechoslovakia 545

EXCISION OF HEMIVERTEBRAE FOR CORRECTION OF CONGENITAL SCOLIOSIS. REPORT OF TWO CASES. *By Edward L. Compere, M.D.*, Chicago, Ill. 555

OSTEO-ARTHRITIS DEFORMANS CONTRASTED WITH OSTEO-ARTHRITIS DEFORMANS JUVENILIS. *By Prof. F. J. Lang*, Innsbruck, Austria 563

OPERATIVE TREATMENT OF CHRONIC DISLOCATION OF THE PERONEAL TENDONS. *By Ellis Jones, M.D.*, Los Angeles, Calif. 574

ECHINOCOCCUS DISEASE OF BONE. REPORT OF TWO CASES INVOLVING THE PELVIC GIRDLE. *By Bradley L. Coley, M.D.*, New York, N. Y. 577

THE TREATMENT OF FRACTURES OF THE SHAFTS OF THE TIBIA AND FIBULA. A NEW TIBIA TRACTION APPARATUS. *By R. Watson Jones, F.R.C.S., M.Ch. Orth.*, Liverpool, England 591

THE TREATMENT OF OSTEOMYELITIS IN THE WARM SALT WATER POOL. *By A. Brockway, M.D.*, Los Angeles, Calif. 611

FLEXION CONTRACTURE OF THE KNEE. THE MECHANICS OF THE MUSCULAR CONTRACTURE AND THE TURNBUCKLE CAST METHOD OF TREATMENT; WITH A REVIEW OF FIFTY-FIVE CASES. *By Jacob Kulowski, M.D.*, Iowa City, Iowa 618

INTERMITTENT HYDRARTHROSIS. *By John L. Porter, M.D.*, and *Robert C. Lonergan, M.D.*, Evanston, Ill. 631

FRACTURE OF THE PATELLA. A NEW OPERATION. *By Frank R. Ober, M.D.*, Boston, Mass. 640

"OSTEOPLASTIC CUNEIFORM OSTEOTOMY" IN THE TREATMENT OF ANKYLOSIS. REPORT OF TWO CASES. *By S. Orell, M.D.*, Styrsö, Sweden 643

AN OPERATION FOR RECONSTRUCTION OF THE INADEQUATE ACETABULUM. *By J. Dewey Bisgard, M.D.*, Chicago, Ill. 655

THE TREATMENT OF JOINT LESIONS IN HEMOPHILIA BY MEANS OF WHOLE BLOOD FROM MENSTRUATING WOMEN. *By Maurice A. Bernstein, M.D., F.A.C.S.*, Chicago, Ill. 659

INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS). *By Maurice M. Pomeranz, M.D.*, New York, N. Y. 663

ARTHROKATADYSIS OF THE HIP JOINT. *By N. Austin Cary, M.D., F.A.C.S.*, and *Leonard Barnard, M.D.*, Oakland, Calif. 687

TUBERCULOSIS OF THE FIFTH LUMBAR VERTEBRA WITH SPINA BIFIDA OCCULTA; SPINAL FUSION AND CURE. CASE REPORT. *By Myron O. Henry, M.D.*, Minneapolis, Minn. 690

REDUCING DIET IN ORTHOPAEDIC SURGERY. *By Emil S. Geist, M.D.*, Minneapolis, Minn. 693

REPORT OF A CASE OF UNUSUAL INJURY TO THE FOREARM. *By Penelope Sherwood, M.D.*, Newburgh, N. Y. 696

SECTION OF THE FLEXOR TENDONS OF THE MIDDLE FINGER OF THE LEFT HAND THROUGH A PALMAR WOUND. PRIMARY SUTURE AND CURE. *By Anthony Andreasen, M.R.C.S.*, Kingston Hill, England 700

A CASE OF HEMANGIECTATIC HEMIHYPERTROPHY WITH SUBJECTIVE SYMPTOMS OF SACRO-ILIAC DISTURBANCE DUE TO ABNORMAL BONY DEVELOPMENT. *By J. E. M. Thomson, M.D.*, Lincoln, Neb. 702

OSTEOGENIC SARCOMA IN CHILD OF THREE YEARS. *By A. L. Craig, M.D., F.A.C.S.*, Honolulu, Hawaii 707

AN ANALYSIS OF PRIVATE ORTHOPAEDIC PRACTICE. *By Richmond Stephens, M.D.*, New York, N. Y. 712

AN ORTHOPAEDIC LEVER FOR CORRECTING DEFORMITIES OF THE FOOT. *By Frederick F. Kortlucke, B.Sc., M.B., Ch.B.*, Edinburgh, Scotland 715

A NEW HIP REST FOR THE APPLICATION OF PLASTER-OF-PARIS SPICAS OR JACKETS IN PRONE OR SUPINE POSITIONS. *By Nathan H. Rachlin, M.D.*, Brooklyn, N. Y. 718

THE ROLLER SKATE AS AN AID TO ACTIVE MOTION AND MUSCLE TRAINING IN CASES OF POLIOMYELITIS. *By Nathan H. Rachlin, M.D.*, Brooklyn, N. Y. 723

NEWS NOTES 724

CURRENT LITERATURE 732

VOL. XIV, NO. 3 JULY, 1932 Old Series Vol. XXX, NO. 3

The Journal of
Bone and Joint Surgery

THE CORRELATION OF EXPERIMENTAL STREPTOCOCCIC ARTHRITIS IN RABBITS WITH CHRONIC RHEUMATOID ARTHRITIS *

BY L. G. HADJOPOULOS, M.D., AND REGINALD BURBANK, M.D.,
NEW YORK, N. Y.

PART I

CLINICAL AND PATHOLOGICAL STUDY OF EXPERIMENTAL ARTHRITIS

The specific relationship of streptococci to the type of joint disease commonly designated as atrophic-deformans has been strongly emphasized by recent research. Clinicians have for many years rightfully suspected an infectious origin, and the metastatic dissemination of bacteria from distant foci of infection—such as teeth and tonsils—has been more and more generally recognized.

Experimental proof of bacterial causation was not generally accepted, because in the past most of the joint lesions produced were of pyogenic nature and not of the serous, productive type found in the human. Differentiation and use of the less virulent streptococci—such as alpha prime, certain viridans, and indifferent forms—eliminated this pus-forming tendency in joint lesions in rabbits, and the experimental arthritis thus produced was of indolent type.

Recent improvements in blood-culture technique have simplified the isolation and culture of streptococci of low virulence in cases of afebrile chronic arthritis; and in our series of more than a thousand cases, at least ten different types of streptococci were isolated from the blood stream of subacute or chronic arthritics. The majority of these strains have been inoculated into rabbits and mice. A series of thirty-eight rabbits have been inoculated in this experimental work with a control in each case. Of the types used, the mannite fermenters, hemolytic as well as viridans,

* From the Pathological Laboratories of Beth Israel Hospital, New York, and Laboratory, 6 East Seventy-eighth Street, New York.

were the most constantly arthrotropic and produced approximately, if not exactly, the same lesions that are found in the arthritic joints of humans.

The technique employed was the intravenous injection of daily doses of one cubic centimeter of a twenty-four-hour broth culture for four consecutive days. The course of events subsequent to the last injection can be summarized under the following three clinical stages:

Stage of Septicaemia.—Duration was usually two to four days. The symptoms were those of a generalized infection with fever, loss of appetite and weight, and at times a concomitant diarrhoea. During this stage, blood cultures were one hundred per cent. positive for the injected streptococcus.

Stage of Selective Localization.—Beginning with the fourth day, there was a gradual return to normal health. Blood cultures were negative in the great majority of cases.

Stage of Acute, Subacute, and Chronic Arthropathies.—The earliest manifestation of joint localization could be elicited the second or third week. An acute onset was common with infrequens strains of hemolytic streptococci, while viridans and indifferent forms produced characteristic subacute and chronic arthropathies. An involved joint usually became progressively worse with a general course of remissions or intermissions, but a very small percentage (under ten per cent.) showed complete spontaneous recovery.

It was rare to find the infective organisms on examination of direct smears of joint exudate but, by culture, positive findings were increased to about fifty per cent. We had no difficulty at any time in culturally demonstrating the presence of the injected micro-organisms in joint scrapings.

PATHOLOGY OF THE EXPERIMENTAL JOINT INFECTIONS

The intelligible exposition of joint pathology caused by hematogenous infection demands a working knowledge of the blood supply of articulations. In the diarthroses the blood supply from the terminal tributaries of the deep vessels is from two separate channels:

(a). The medullary vessels entering the nutrient foramina supply the bone and bone-marrow. Both epiphysis and diaphysis have individual branches which terminate in the neighborhood of the epiphyseal cartilage. Cartilage itself is devoid of direct blood supply and there is no anastomosis between these terminal branches until adult life, when the cartilage is absorbed in the process of epiphyseal-diaphyseal union.

(b). Synovial vessels supply the joint capsule and the synovial sheaths, anastomosing with the terminal branches of the periosteo-perichondrial tributaries (Fig. 1).

Since the progressive pathological changes are directly related to the histological stage of development in a joint, we are confining our observations to the relatively young joints in which union of the epiphysis and

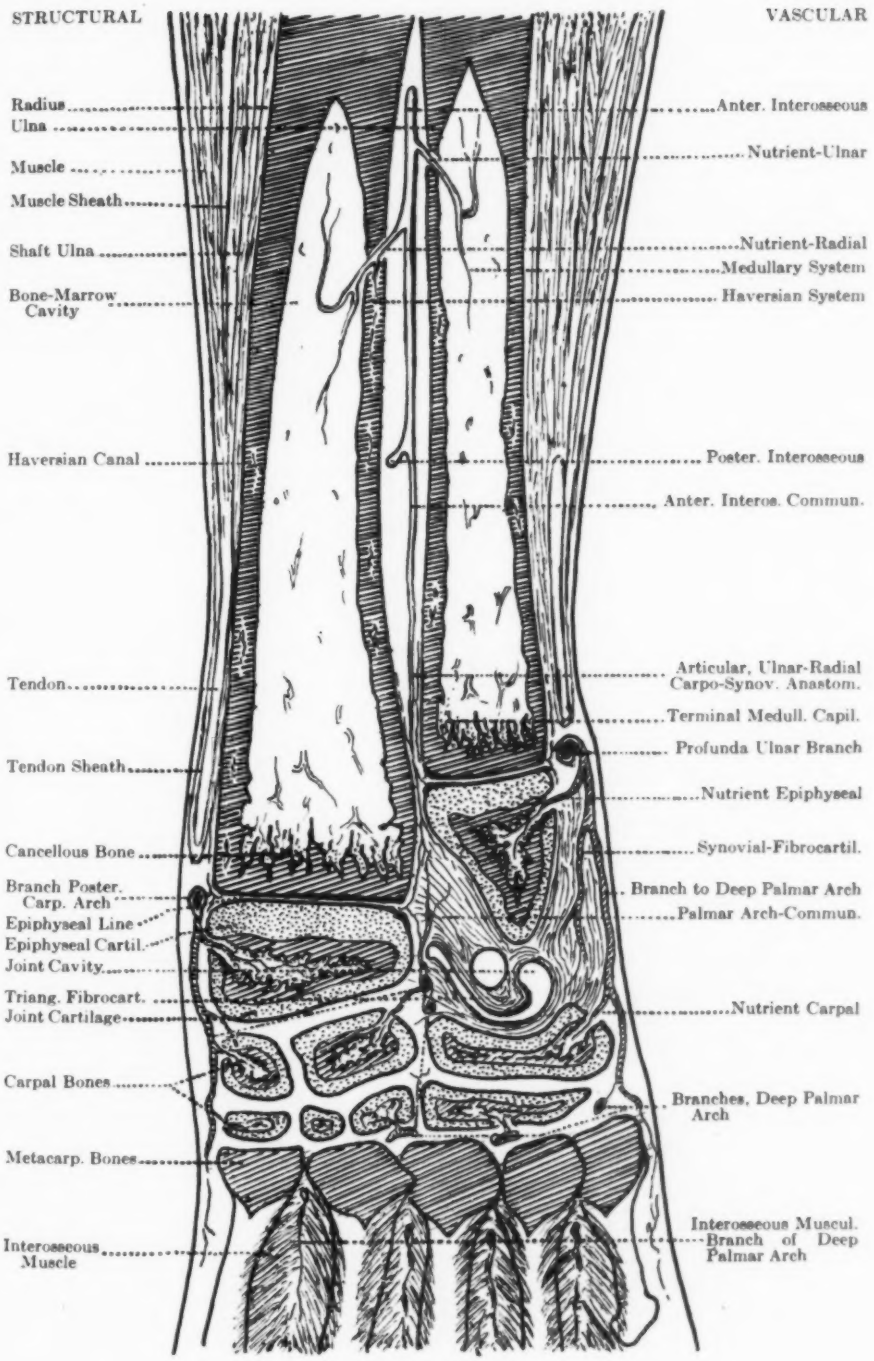

FIG. 1

Diagrammatic presentation of a rabbit's wrist joint. The vascular supply is described at the right-hand side. The left-hand side deals with the various structures that make up the joint.

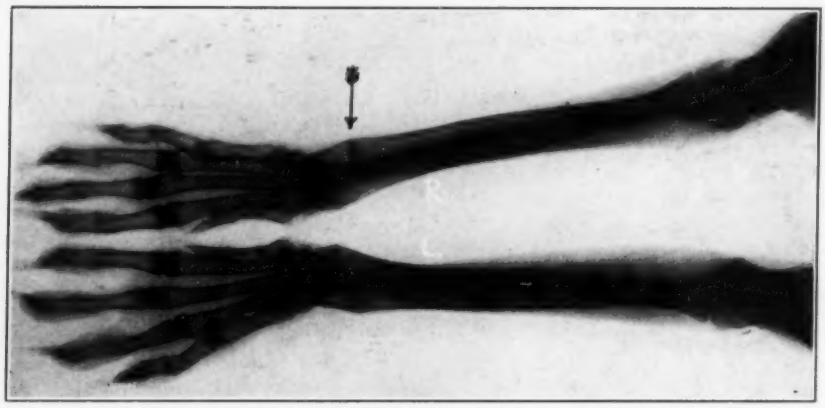

FIG. 2

Roentgenogram of a normal wrist joint. The arrow points to the epiphyseal line and the epiphyseal cartilage.

diaphysis has not been completed. Three stages are definitely distinguishable:

The Pre-Exudative Stage

The duration is usually from a week to a month. During this interval selective localization of the infective agent has taken place through the medullary blood supply in its terminal branches. Clinical evidence of any synovial infiltration is still lacking.

The roentgenogram of a normal joint before the complete union of the epiphysis shows a uniformly clear straight line with a relatively narrow band of epiphyseal cartilage below it (Fig. 2). With the onset of localization of the arthritic lesion the epiphyseal line becomes distorted, and

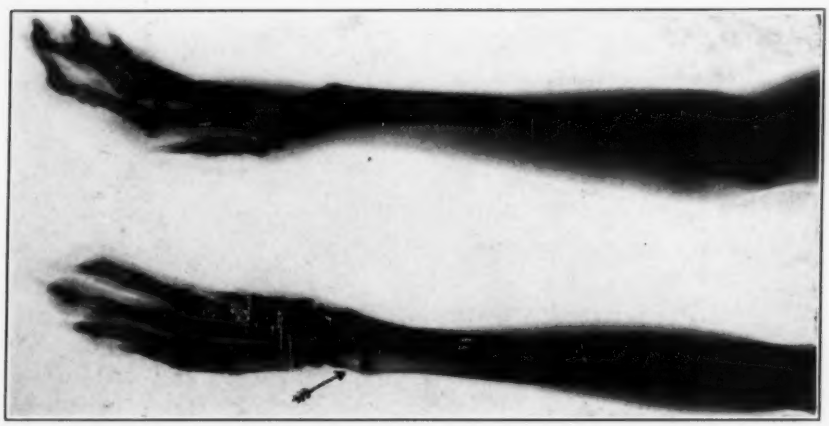

FIG. 3

The earliest signs of a localizing infection in the epiphyseo-diaphyseal region of the lower end of the ulna. The epiphyseal line is broken at its center by a well defined circumscribed lesion. External to it, there is a diffuse infiltration involving the lateral aspect of the diaphysis of the radius.

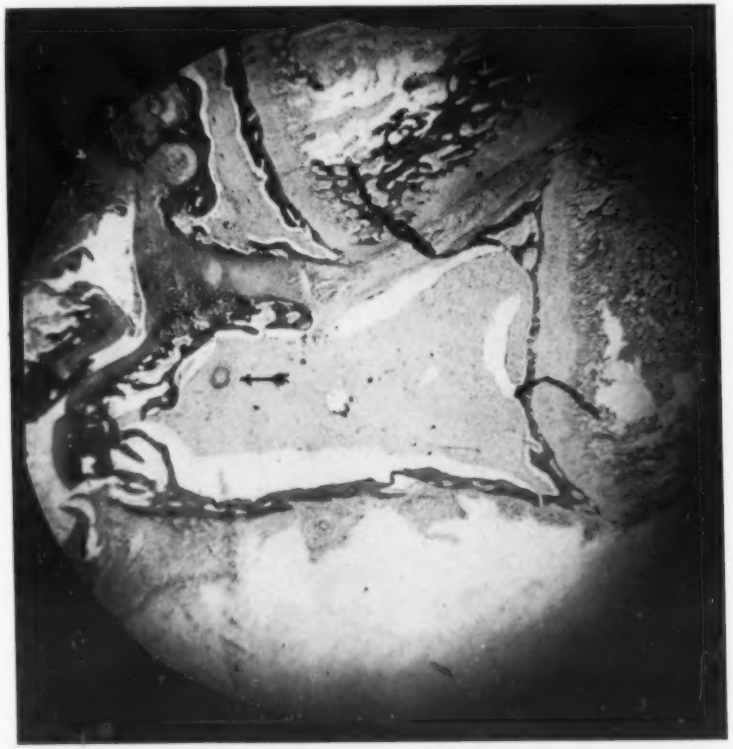

FIG. 4-A

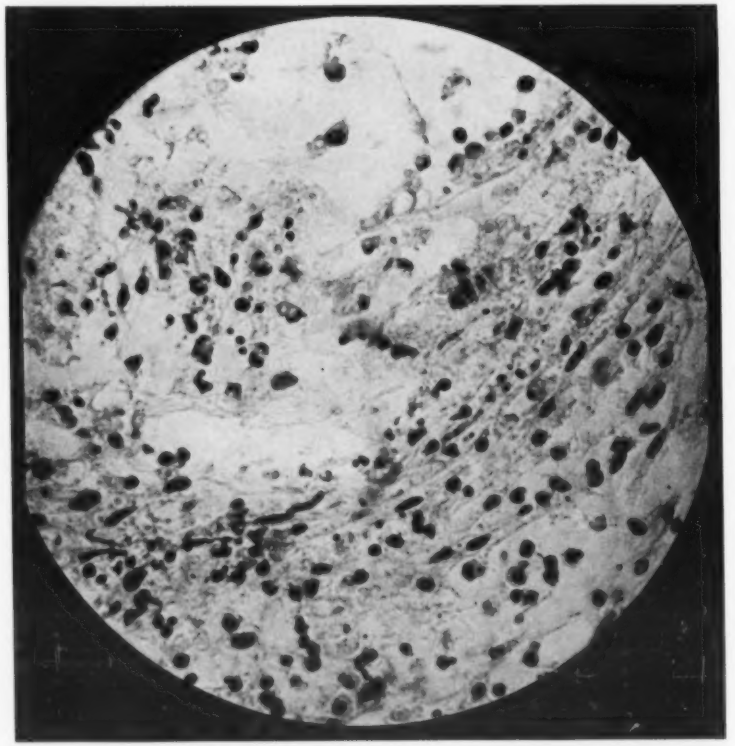

FIG. 4-B

Focal infection in the bone marrow of the ulnar epiphysis.

A low-power view of a localizing chronic infection with a central area of necrosis surrounded by a dense zone of infiltration.

A higher magnification of same, showing part of the central necrotic area and the round-cell infiltration at its periphery.

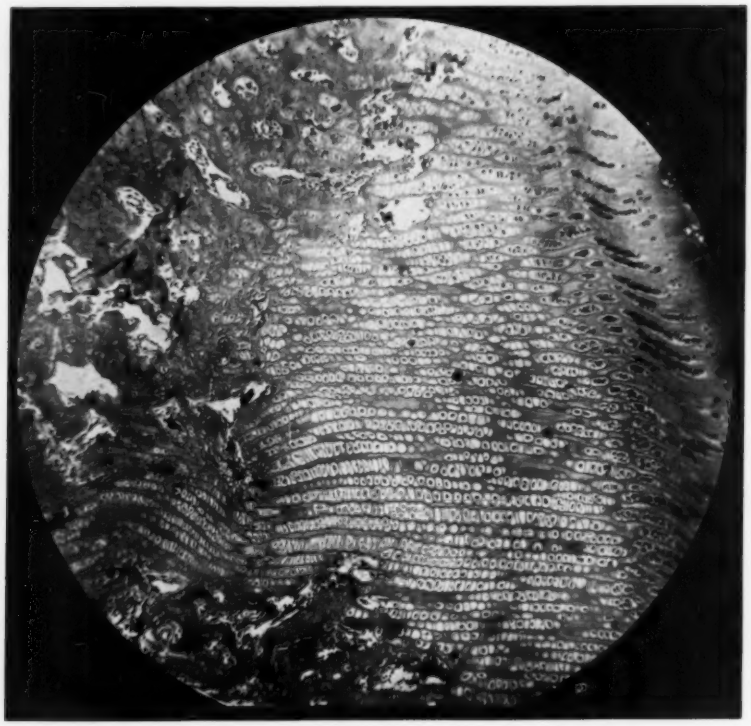

FIG. 5

Diffuse opacities along the epiphyseal line and epiphyseal cartilage. Buds of proliferating vascular and osteoblastic tissues invading the epiphyseal cartilage. The cartilage is also abnormally active with complete loss of its normal boundaries.

clearly circumscribed or diffusely scattered, hazy opacities appear in its course (Fig. 3). Microscopically these circumscribed opacities show various stages of the early stigmata of a localizing chronic infection. There is a central area of degeneration, which may go to complete necrosis, and a periphery of marked round-cell infiltration, mainly lymphocytic, but interspersed with connective-tissue cells (Figs. 4-A and 4-B).

The diffuse opacities are buds of proliferating vascular and osteoblastic tissue invading the epiphyseal cartilage. The cartilage itself likewise undergoes proliferative changes. Columns that in quiescence would contain two to four cartilage cells show anywhere from ten to forty (Fig. 5). The outlines of the cartilage are broken down and the pathological picture simulates that of rachitis (Figs. 6-A and 6-B).

Changes concurrent with the second or exudative stage gradually supervene and the rachitic picture changes to a true exudation.

The Exudative Stage

This period is especially characterized by inflammatory changes limited to the soft tissues of the joint, chiefly the synovial membrane and its

FIG. 6-A

Extreme changes in a prolonged pre-exudative stage simulating rachitis.
A photograph of the wrist joints of a rabbit, the microscopic picture of which is shown in Fig. 5.

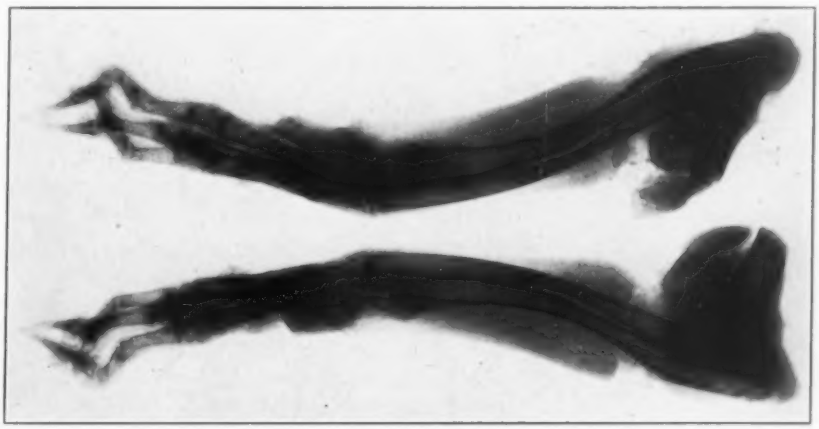

FIG. 6-B

The roentgenogram of the same wrists showing practically no exudate, but sufficient enlargement of the joint boundaries, with a relative osteoporosis and marked bowing of both ulna and radius.

appendages: the perichondrium, the periostium, and the synovial sheaths of tendons and muscles. These inflammatory processes develop independently of the structural bony changes just described, because the hematogenous origin of the infection carries it by a separate blood supply to the synovia.

The onset of exudation though synchronous with the pre-exudative stage is ordinarily insidious and passes unnoticed until sufficient fluid is present to be discernible or demonstrable by x-ray. Onsets of an acute nature are not at all uncommon with strains of hemolytic streptococci that are arthrotropic. Sometimes there is single joint involvement, such as an acute interphalangeal exudation (Figs. 7-A and 7-B). More fre-

FIG. 7-A

Acute exudative inflammation of the metacarpophalangeal joint of the index digit.

FIG. 7-B

Photograph of the animal in Fig. 7-A, protecting the involved extremity.

quently one or both wrists are affected (Fig. 8); less frequently an ankle (Fig. 9). Viridans strains nearly always give an exudative stage of insidious onset.

The clinical signs of exudation—such as local heat, redness, swelling, tenderness, stiffness, and pain on active and passive motion of the affected joints—are so familiar that a lengthy discussion of them is not required.

Under the influence of the inflammatory process the synovial lining secretes more fluid than the normal joint cavity would contain. The character of the fluid depends on the nature and intensity of the inflammation. It may vary from a clear, mucinous, straw-colored fluid with only a few mononuclear cells to a thick, grumous exudate with numerous desquamated synovial and mononuclear cells. Leucocytes may be present. There is usually abundant mucous and fibrin. Occasionally the fluid may even be hemorrhagic.

The key to the pathological interpretation of the exudative signs is found in the abnormal hyperaemia of the synovial stroma (Figs. 10-A and 10-B). The effects are: first an active, then a passive congestion, and finally an overgrowth of the endothelial lining of the capillaries which gradually leads to an ischaemia. This ischaemia is the essential characteristic that in its course of successive intermissions and remissions, tending steadily to chronicity, gradually prepares the ground for the third or final stage.

Stage of Alternate Regeneration and Degeneration

The signs and symptoms of the preceding stages gradually blend together and become more intensified, while the disease runs its progressively active course. The duration is indefinite. It may terminate in either spontaneous recovery or be cut short by treatment. In either case, one may still find more or less permanent stigmata of tissue changes from infection. The usual course, however, is that of simultaneous regenerative and degenerative reactions influenced by the histological nature of the involved tissues. Therefore, it is pertinent in

the analysis of the related pathological studies to follow a definite plan based on histogenesis.

CHANGES INVOLVING THE BONE-MARROW

Normally the structure of bone-marrow depends on age. In young animals it is a highly vascular-cellular structure in a thin network of reticular connective tissue (Fig. 11). With advance of life, the cellular element is replaced gradually by fat.

The earliest changes in an infected marrow have already been dealt with under the former stages (Figs. 4-A and 4-B). The subsequent changes are mostly of a degenerative nature, involving all types of marrow cells,—*viz.*, the erythrocytic and leucocytic hemopoietic system. The connective-tissue reticulum reverts to active proliferation in an attempt

FIG. 8

Acute exudative inflammation involving both wrist joints. The above is a typical picture of the acute stage of an exudative atrophic-deformans infection that may occur in the human subject. In addition to the exudation, note the characteristic bone and cartilage pathology and the marked ulnar-deviation deformity.

FIG. 9

Acute exudative inflammation of the ankle. Advanced stage of an exudative atrophic-deformans lesion of the ankle joint with marked exudation and almost complete atrophy of the astragalus.

FIG. 10-A

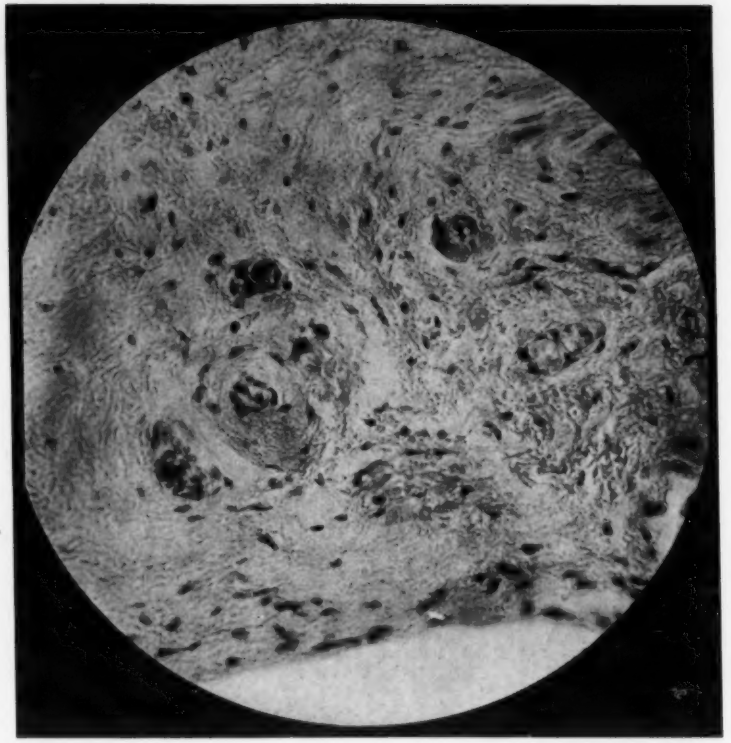

FIG. 10-B

Abnormal vascularization of the synovial stroma.

In the centre of the picture there is a thick synovial villus projecting into the joint cavity. The stroma of this villous overgrowth is abnormally vascular.

The endothelial lining of the synovial blood vessels is found in a stage of active proliferation, thereby interfering with the circulation of the tissues.

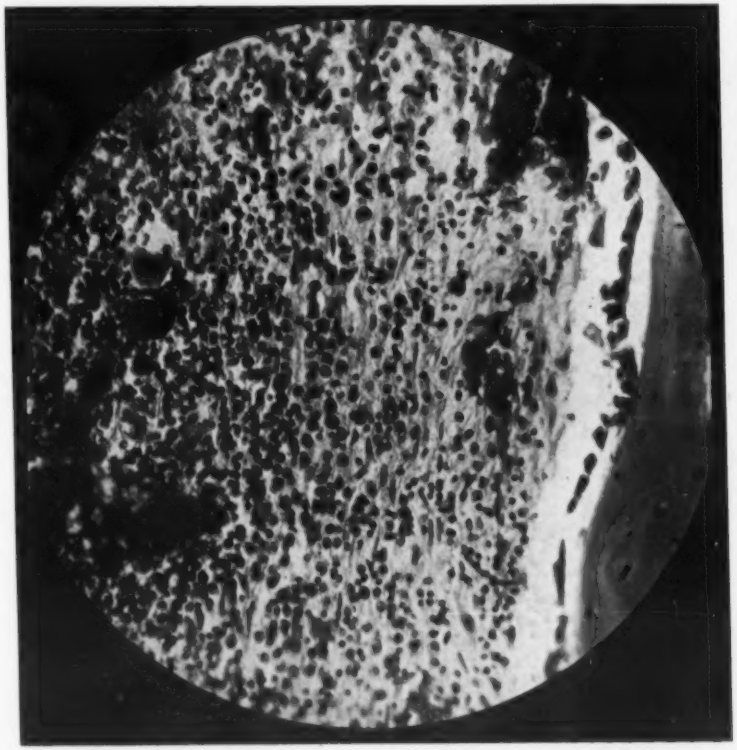

FIG. 11

Normal bone-marrow of young rabbit. Part of the shaft of bone with its osteoblastic layer is seen at the right of the picture. The rest is bone-marrow of normal consistency. Compare with Fig. 12.

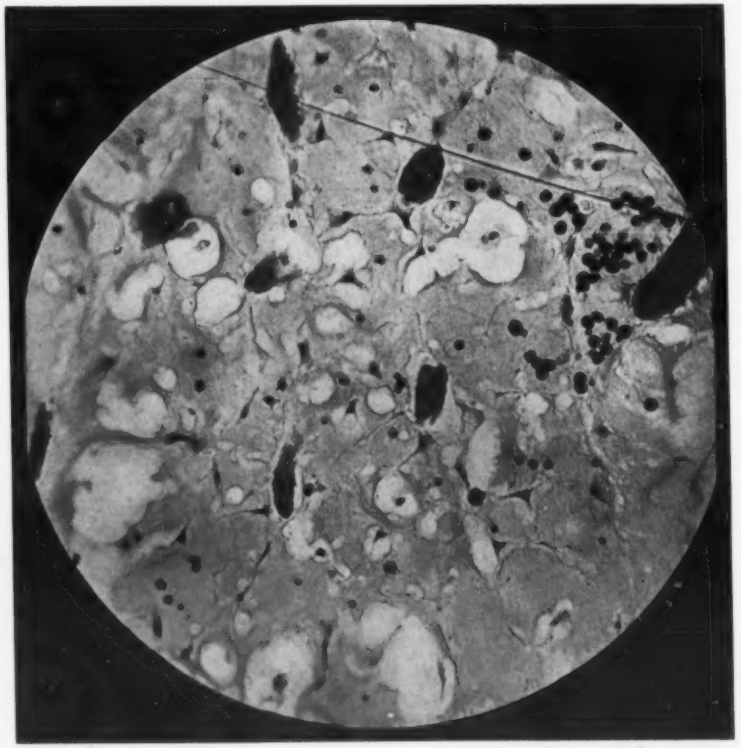

FIG. 12

Bone-marrow in an advanced atrophic-deformans infection. The reticular connective tissue has taken the place of the fast disappearing hemopoietic cells, a small group of which can still be seen at one side of the picture. Note the marked contrast between this picture and Fig. 11.

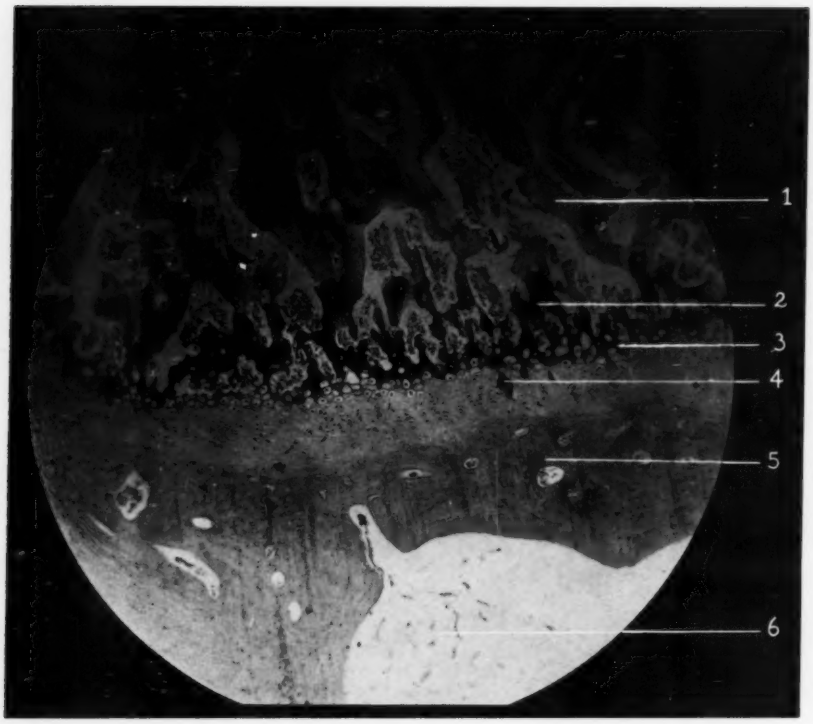

FIG. 13

Osteoblastic activity in the region of cancellous bone.

1. Cancellous bone trabeculae in diaphysis undergoing decalcification.
2. Osteogenetic layer with marked calcium infiltration.
3. Invasion of the epiphyseal line by osteogenetic tissue.
4. Islands of new bone in epiphyseal cartilage.
5. Epiphyseal bone.
6. Epiphyseal bone-marrow having undergone fatty degeneration.

to replace the fast disappearing marrow cells. Similarly there is an increase in fat cells. In other words, we observe a premature aging of the bone-marrow with a marked shrinkage of the vascular supply (Fig. 12).

CHANGES IN BONE

In the region of cancellous bone and the endosteum of the shafts, the osteogenetic tissues, under the influence of infection, are spurred to abnormal activity. As a result new bone trabeculae are seen interlacing in the marrow spaces, and there is a thickening of the shaft. At the same time, bands of osteoblastic buds with their increased vascular supply invade the epiphyseal cartilage and deposit small islands of bone in its matrix (Fig. 13). These changes, however, are not of a permanent nature, as an equally abnormal activity of the osteoclasts supervenes and absorbs: first, most of the newly formed bone (except in the cartilage) and, later, both new and old calcification, this giving rise to a relative

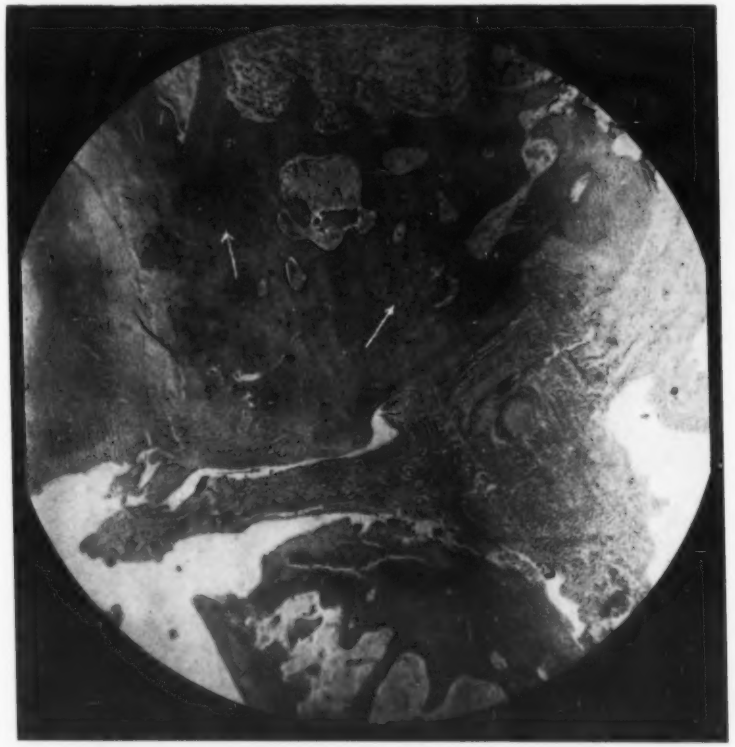

FIG. 14-A

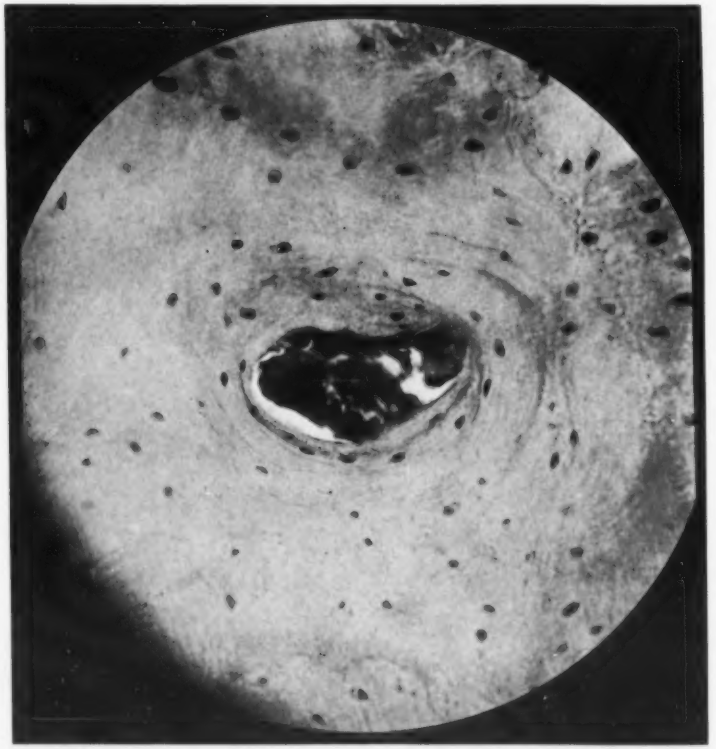

FIG. 14-B

Bone pathology resulting from vascular changes in the haversian system.

The arrows in the epiphysis point to occluded haversian canals. The bone at this area has undergone degenerative changes of a necrotic nature, as is clearly outlined in the slide by its dark bluish color.

A high-power view of one of these occluded haversian canals. The entire cavity is filled with a structureless necrotic tissue. No trace of vascular structure can be seen.

FIG. 15

Productive bony changes characteristic of osteo-arthritic lesions. The arrows point to osteophytic extensions projecting from the olecranon and coronoid processes into the soft tissues of the elbow.

FIG. 16

Complete bony union between epiphysis and diaphysis with disappearance of the epiphyseal cartilage.

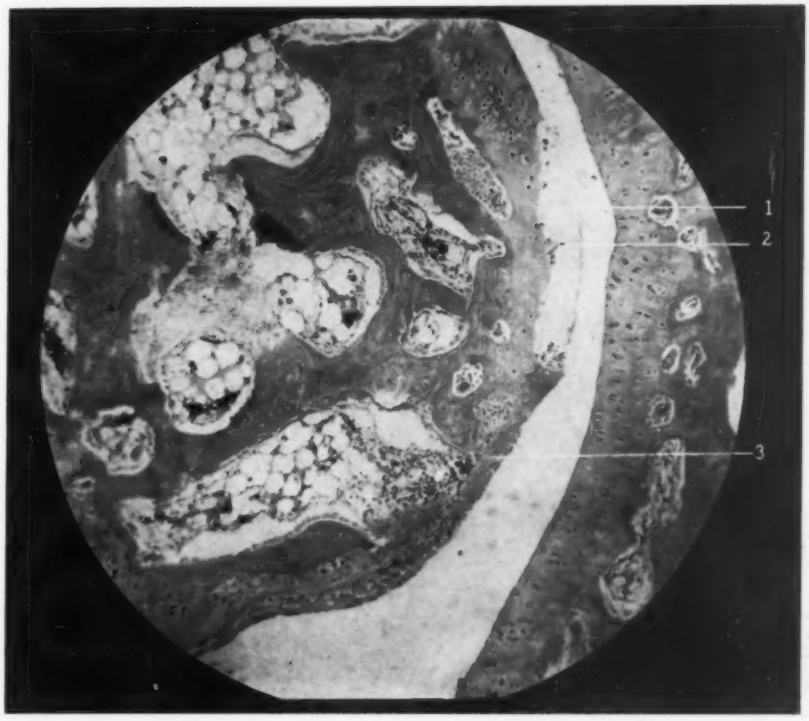

FIG. 17

Changes in cartilage.

1. Area of liquefaction necrosis with the normal boundaries of cartilage still visible.

2. A bud of connective tissue growing into the necrotic area.

3. Connective-tissue replacement of denuded joint cartilage, resulting in an indentation of the joint surface.

osteoporosis. Further changes in the epiphyseal cartilage will be considered later.

So far all the regenerative and degenerative changes in the bone tissues are but phases of an exaggerated physiological activity with the difference that what age would ultimately do over a period of years, the infection accomplishes in weeks or months. This again is a premature aging as in the case of the bone-marrow changes.

The real degenerative changes in bone are primarily of vascular origin. In the areas supplied by the final tributaries of the haversian system, especially at the ends of long bones, we may occasionally discover occluded vessels of the size of arterioles or capillaries. More commonly we see a marked narrowing of their lumen due to endothelial proliferation. The bone adjacent to these areas loses its normal texture, and becomes basophilic. The lamellar markings become more prominent, but later are completely lost during the process of decalcification (Figs. 14-A and 14-B). Whether a collateral circulation would eventually be set up could not be determined.

FIG. 18

Fibrous ankylosis.

1 and *2*. Fibrous ankylosis between epiphysis and the carpal bones.
3. Pannusitis of the hyaline cartilage of one of the carpal bones.
4 and *5*. Normal joint surfaces.
6. Destruction of epiphyseal cartilage, exposure of bone, filling of the gap with synovial connective tissue.
7. Joint cavity partly obliterated by villous proliferation of synovial tissue and loose bodies.

Productive changes of bone, characteristic of osteo-arthritic lesions, —such as lipping of joint surface, bony overgrowth into the joint cavity, or spicules in soft tissues—and the deformity and discomfort accompanying them, are not common in this type of infection. Nevertheless, they occur at certain stages of the disease and occasionally persist indefinitely (Fig. 15).

CHANGES IN CARTILAGE

The epiphyseal cartilage that has previously been invaded by the medullary osteoblastic buds undergoes a gradual shrinking in size and eventually is replaced by new bone. The result is a complete bony union between epiphysis and diaphysis (Fig. 16).

The changes in the joint cartilage are of a different nature: The destruction of cartilage, so common in infected joints, is the end result of a chain of preceding changes, which in order of occurrence are:

(1). A liquefaction necrosis, where one can still see the outline of the cartilage but no matrix and cells (Fig. 17).

(2). Invasion of this liquefaction area by connective-tissue cells and new blood vessels.

(3). A moderate contraction of the invaded connective tissue, resulting in an indentation of the joint surface (Fig. 17).

Usually, in a pathological joint, there is sufficient synovial fluid to prevent friction. This connective tissue may persist, or may eventually undergo ossification unless certain other factors supervene:

(a). If such an area is close to the synovial membrane and adjacent to a similarly involved joint surface, fibrous union may take place (Fig. 18).

(b). If, for any reason, the synovial fluid decreases sufficiently to cause friction in these denuded areas, every active and passive

FIG. 19

Generalized oedema of the extremities. In addition to the extensive atrophic-deformans pathology of both wrists, there is a generalized oedema of the soft tissues extending well above both elbow joints.

FIG. 20

Radial deviation and flexion deformity. Roentgenogram of an extreme case of atrophic-deformans infection showing marked destruction of carpal bones of both wrists. The ankylosis in the right wrist is fibrous; in the left, both fibrous and bony. The resulting deformity is typical of the radial-deviation kind. (See also Fig. 19). For the ulnar-deviation type of deformity, see Figs. 8 and 6-A.

motion becomes painful. A progressive form of this stage may lead to complete destruction of joint cartilage, exposure of bone, and finally eburnation.

Bony exposure and eburnation, however, rarely take place because there is usually sufficient fluid present, and extreme sensitiveness on motion serves to protect against undue friction. It occurs more commonly in relatively less painful joints of the osteo-arthritic, hypertrophic type.

CHANGES IN SYNOVIAL TISSUES

The earlier changes in the synovial sac and its appendages have been discussed. Subsequent changes depend on the anatomical relationship of the synovial sac with other joint tissues. We have, therefore:

(a). *Synovial-tissue changes in relation to the joint cavity:* During the exudative stage, the joint cavity has already been enlarged by the abnormal accumulation of fluid, due to the simultaneous working of two factors: firstly, an abnormal hyperaemia of the synovial sac; secondly, and of greater moment, the direct activity of the synovial cells. If this activity is not arrested naturally, it gives rise to villous outgrowths into the joint cavity. It is possible for some of these villi to become detached from their pedicles and lie free in the cavity as loose bodies (Fig. 18). Usually, however, the pedicle is broad enough and contains sufficient blood supply to grow unhampered and almost fill the joint space (Fig. 16, also Fig. 14-A).

(b). *Changes of the joint capsule proper:* In addition to the proliferation of the synovial lining we notice a thickening of the synovial stroma. The increased vascularization gives it a spongy texture with a dense network of connective-tissue fibers (Fig. 10-A). With the gradual advent of endarterial changes, the joint capsule becomes relatively ischaemic, but its contour is not altered thereby, due to its heavy connective-tissue reticulum. There can also be complete fibrosis of the synovial tissues.

(c). *Synovial-tissue changes in relation to cartilage and bone:* The joint cartilage, near the attachment of the capsule is now covered by a thin membrane, the pannus (Fig. 18) which, at first structureless, is soon infiltrated by fibrous tissue from the synovialis which may give rise to localized fibrous ankylosis. The bone is not directly involved in relation to the synovial membrane unless there is sufficient cartilage destruction to result in exposure of the bone. If this occurs, and it is relatively uncommon, the pathological changes are similar to those found in the case of cartilage destruction (Fig. 18). New bone formation in synovial tissues may originate possibly from a reversion of fibroblastic to osteoblastic cells. It is, however, not common in this type of infection.

(d). *Synovial tissue changes in relation to periosteum, tendon, and muscle sheaths:* Anatomically, the periosteum, the tendon, and muscle sheaths are continuations of the joint capsule. During the course of development, although their continuity is lost, they are still contiguous tissues of the same histological structure. Consequently, it is natural

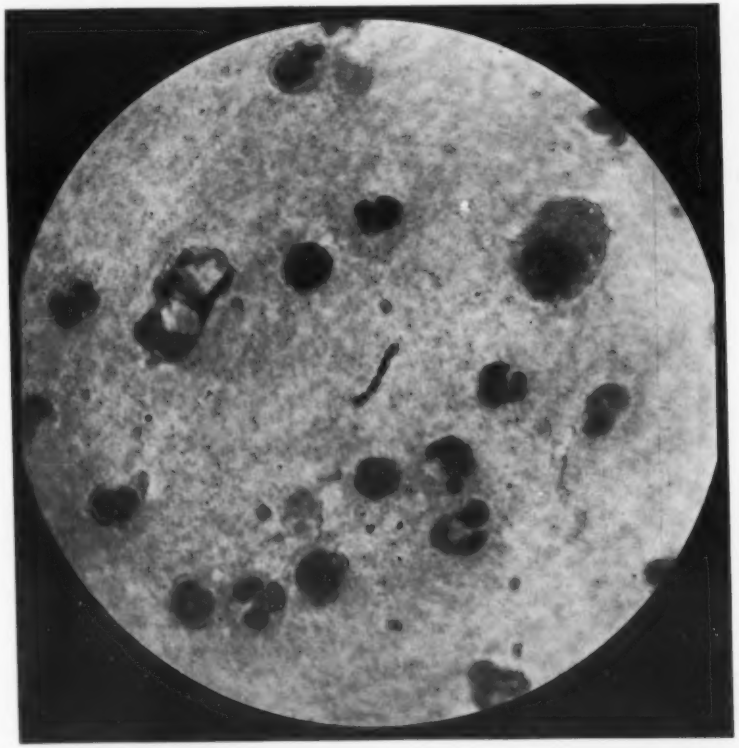

FIG. 21-A

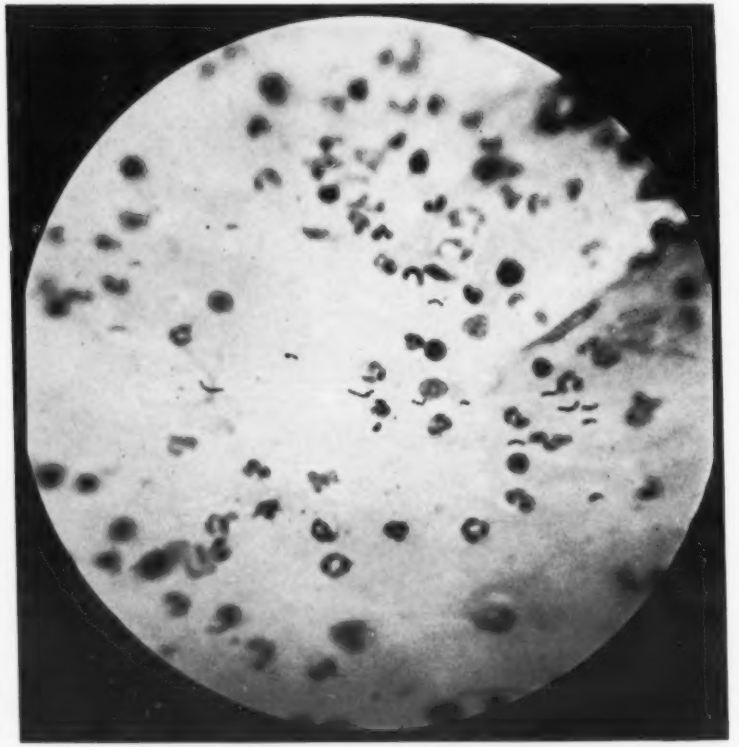

FIG. 21-B

Dissemination of streptococci in synovial fluid.

Direct smear of synovial fluid stained with the Gram method.

Smear of synovial fluid after subjecting the joint to the special culture method without breaking the synovial capsule.

to expect changes of a similar nature when infection occurs in these tissues.

The periosteum is thickened and may even revert to its osteoblastic property. At the attachment of the tendons there is an abnormal proliferation of tendon cells. The tendon sheaths are also moderately swollen, and contain more fluid than normally. The same process may extend to the muscle sheaths. Finally, a localized oedema of the soft tissues may occur (Fig. 19). Groups of large muscles may undergo gradual atrophy of disuse. With improvement in the joints and more liberal use, they may gradually recover their tonus and nourishment. The atrophic changes in the group of small muscles, like the abductors and adductors of fingers and toes or the digital interossei, are usually of a more permanent character. The vascular supply of the interossei is from the same source as that of the joint proper; consequently, when extensive endarterial changes exist in these terminal branches, their blood supply is seriously interfered with. This fact and the hematogenous distribution of infection in close proximity to the joint may be contributing factors to the early atrophy, so commonly encountered in these muscles. A peculiar characteristic of these atrophic changes is that these muscles are usually involved in groups according to their anatomical position and function, abductors are more commonly involved than adductors, and flexors more than extensors, this giving rise to the commonly encountered abduction and flexion deformities (Figs. 19 and 20, also Figs. 8 and 6-A).

SUMMARY AND DISCUSSION

It has been possible by injecting certain mannite-fermenting arthrotropic streptococci, isolated from the blood stream of afebrile arthritic patients, to produce in rabbits pathological lesions exactly comparable to those found in chronic arthritis in the human being.

This fact has also been substantiated by the almost complete similarity of the morbid anatomy of our streptococcic arthritic joints in rabbits to those naturally acquired in the human subject, and so carefully investigated and described by Nichols and Richardson, Llewellyn and Jones, Strangeway, Knaggs, and others.

Most of this morbid anatomy and the concomitant symptoms we were able to trace directly or indirectly to changes in capillary circulation, a finding which Pemberton upholds and ascribes to some toxic degeneration, either associated with or merely followed by disturbed metabolism.

Since toxic degeneration in capillaries is a common finding in the course of chronic disease, and because of the recent revival of the hypothesis that the changes of atrophic rheumatoid arthritis are toxic anaphylactic manifestations (Swift, Boots), we felt that the direct effect of infection on joints should first be definitely excluded before theorizing on the basis of indirect factors. In acute inflammatory conditions of a pyogenic nature, the demonstration of the causative micro-organism in diseased tissues is usually taken as a sufficient evidence of the direct ac-

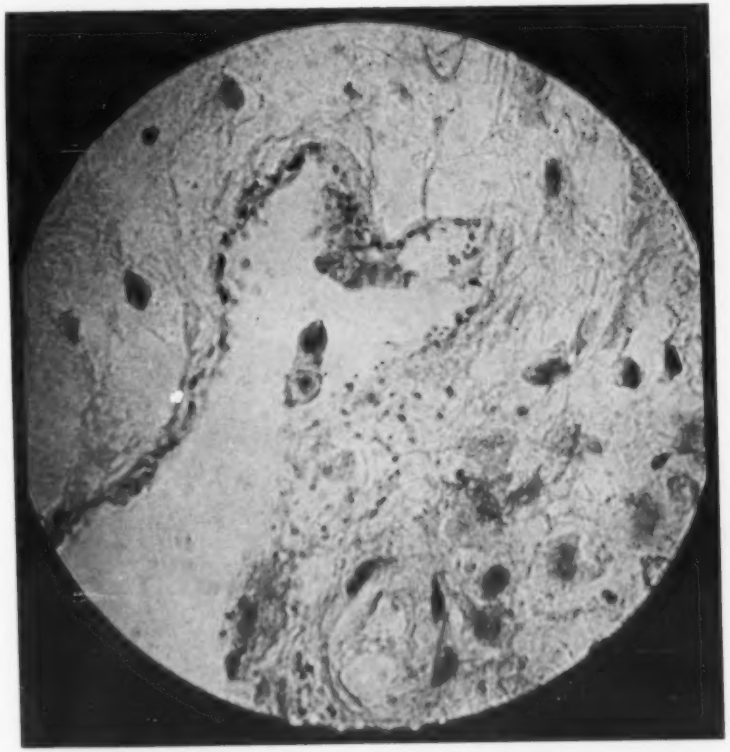

FIG. 22-A

Dissemination of diplococci in the synovial lining and subsynovial tissue.

FIG. 22-B

Dissemination of diplococci in the synovial stroma.

Demonstration of streptococci in synovial tissue.

tivity of the invading germ (the demonstration of gonococcus in gonorrhoeal arthritis or of staphylococcus in carbuncles). Changes in remote tissues or organs from which the presence of bacteria is excluded may be considered indirect degenerative alteration of a toxic or allergic nature.

We felt it necessary to exhaust all possible means of demonstrating the dissemination of streptococci in diseased tissues of our experimental animals before we ascribed such changes as were present to indirect causes such as toxaemia or allergy.

PART II

THE RÔLE OF STREPTOCOCCUS IN THE PATHOGENESIS OF JOINT LESIONS

The toxic or allergic theory of the pathogenesis of chronic rheumatoid arthritis owes its existence to the inconsistency of the cultural findings and the totally unsuccessful attempts to demonstrate the presence of bacteria in tissue sections.

The similarity of arthritis as produced in rabbits to that naturally acquired by the human subject, coupled with the fact that we never failed to isolate the injected streptococcus from cultures of scrapings from the affected joints, compelled a thorough revision of our investigation of this subject.

Our early attempts to demonstrate streptococci in tissue sections were uniformly unsuccessful. Various methods of tissue-fixing and bacteria-staining were resorted to, but all we could find were pleomorphic gram-positive granules, occurring singly or at times in pairs, in the neighborhood of the epiphyseal line and in close proximity to the terminal medullary capillaries.

The regularity of these findings developed in us a conviction that these gram-positive granules might be involution forms of streptococci. If they were viable, by culturing such tissues, their true morphology could be restored. The following technique was used:*

Animals with definite arthritic lesions were killed by stunning. After shaving off the hair, the skin of the extremities was carefully removed, and the infected joint severed *in toto*, leaving about a quarter of an inch of bone both above and below the joint. The dissection was performed under sterile precautions, and with the least manipulation and injury possible. The entire severed articulation was then placed in neutral bouillon containing two per cent. peptone and incubated for from three to six days, depending on the thickness of the tissues. It was then washed in sterile saline and fixed in formalin. For decalcifying we used a mixture of equal parts of saturated (eighty-five per cent.) formic acid and twenty per cent. solution of sodium citrate. Of all the bacterial stains the Gram

*This technique was used by Dr. Eugen Frankel in Hamburg for demonstration of typhoid bacilli in roseola.

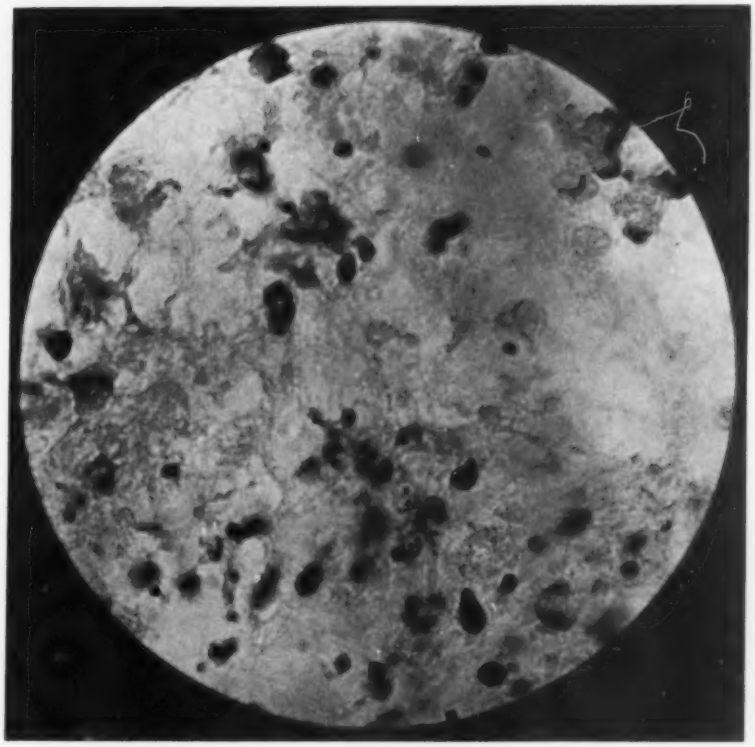

FIG. 23

Demonstration of streptococci in bone-marrow. The above picture is the high magnification (oil) of Figs. 4-A and 4-B. In the zone of lymphocytic infiltration there are seen streptococci in single and diplococcic forms.

method was the best as a differential stain, while the methyl-green pyronin proved superior for demonstration purposes.

Carrying out the above technique under strictly aseptic precautions was not an easy task. With all due care, cultures were at times contaminated by saprophytic bacilli or staphylococcus albus. Although this is highly undesirable, the experimental results are little affected by their presence. Staphylococci, being non-motile, will never penetrate into the tissues of the joint proper. Their presence on the surface or immediately under it need not be taken into consideration. Bacillus subtilis, on the other hand, being actively motile, can penetrate into any part of the joint by following the blood and lymph channels. Fortunately, however, it can scarcely be mistaken for streptococcus on account of its size and clear-cut morphology. Normal joints were also incubated in bouillon cultures of streptococcus, staphylococcus, and bacillus subtilis, and although all these types of micro-organisms could be demonstrated on the surface of tissue, only the motile bacillus penetrated the tissue parenchyma.

As the analysis of the pathogenesis of focal lesions of hematogenous origin requires an adequate knowledge of the regional blood supply, the

FIG. 24

Demonstration of streptococci in the haversian system. The arrow points to a haversian system tributary in the loose connective tissue of which diplococci were found.

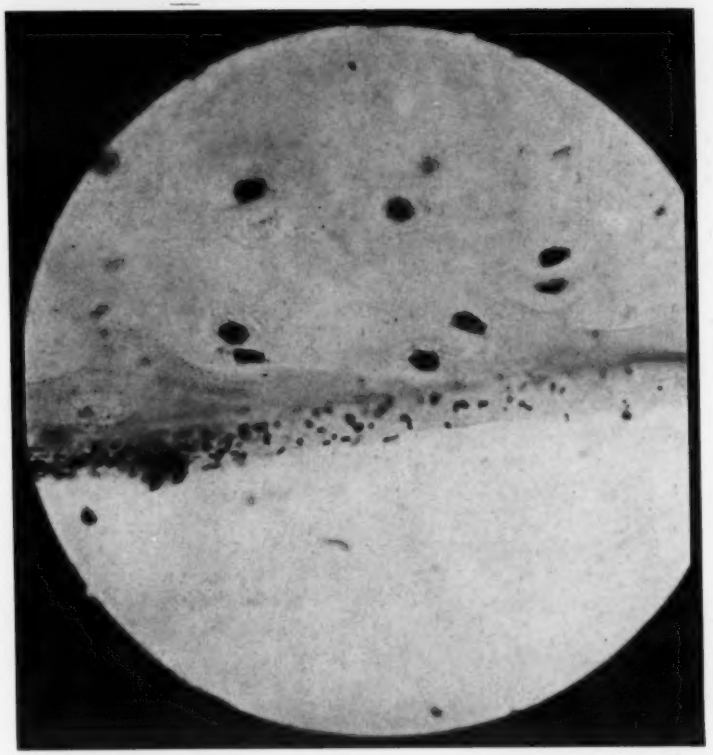

FIG. 25

Demonstration of streptococci in cartilage. The joint surface of hyaline cartilage is covered with a thin membrane which is densely infiltrated with diplococci.

FIG. 26-A

High-power magnification (dry) of epiphyseal cartilage, showing invasion of osteoblastic tissue. The cartilage cells of the invaded area have lost their nuclei and their protoplasm has become granular.

FIG. 26-B

High-power magnification (oil) of Fig. 26-A, showing streptococcic infiltration of degenerated cartilage cells.

Demonstration of streptococci in degenerated cartilage cells.

investigation of blood-carried microbic dissemination should follow an identical course. Of the tissues that make up the joint, the bone and synovial sac have each an independent blood supply. The cartilage is the only tissue that has no direct arterial contribution; but it is located close to terminal branches of vessels of the bone and bone-marrow, both proximally and distally, and to the synovial vessels laterally (Consult Figure 1).

In demonstrating the streptococcic dissemination in joints we will take the vascular tissues first and leave the avascular cartilage until the last.

DISSEMINATION OF STREPTOCOCCI IN SYNOVIAL TISSUES

The demonstration of streptococci in synovial fluids without resorting to cultural procedures is difficult, but they can be demonstrated occasionally during the acute phase of the disease (Fig. 21-A), especially when the fluid is slightly hemorrhagic. When synovial fluid is subjected to the culturing method *in situ* as described above, demonstration becomes relatively easy (Fig. 21-B). The true morphology of the streptococcus in such fluid media as the synovial exudate is strikingly characteristic, — chains of four to eight or more can be demonstrated easily.

The next site where streptococci can be found in abundant growth is the inner synovial layer (Fig. 22-A). Here, however, they occur mostly in diplococcic forms and occasionally in chains of three or four.

In the stroma of the synovial sac, the streptococci invade the proliferating connective-tissue fibers and they are situated for the most part under the lining (Fig. 22-B). The blood vessels are invariably free from streptococci, although they are originally the channels through which dissemination takes place. We attribute this to the bactericidal property of the blood. Were it not for this power, a persistent septicaemia would ensue. The cause of intermittent septicaemias, usually of an abortive nature, will be explained in discussion of the involvement of internal organs.

DISSEMINATION OF STREPTOCOCCI IN BONE

The nutrient vessels supply the bone-marrow and through the haversian system the bone proper. The bone-marrow is usually free from bacteria because of the phagocytic property of its cellular elements. In the case, however, of focal infections occurring in the marrow, streptococci can be demonstrated at the periphery of the central necrotic area in the zone of round-cell infiltration (Fig. 23 and Figs. 4-A and 4-B).

Bone tissue proper is impervious to streptococci. The microbic dissemination takes place through the haversian system and can be carried to its terminal branchings. For reasons already given, streptococci could not be demonstrated in the lumen of blood vessels; but in the loose connective-tissue framework of the smaller and terminal haversian canals, streptococci in diplococcic forms could be occasionally demonstrated as shown in Figure 24.

FIG. 27

Demonstration of streptococci in tendons. Streptococci invading the tendon as indicated by the arrow.

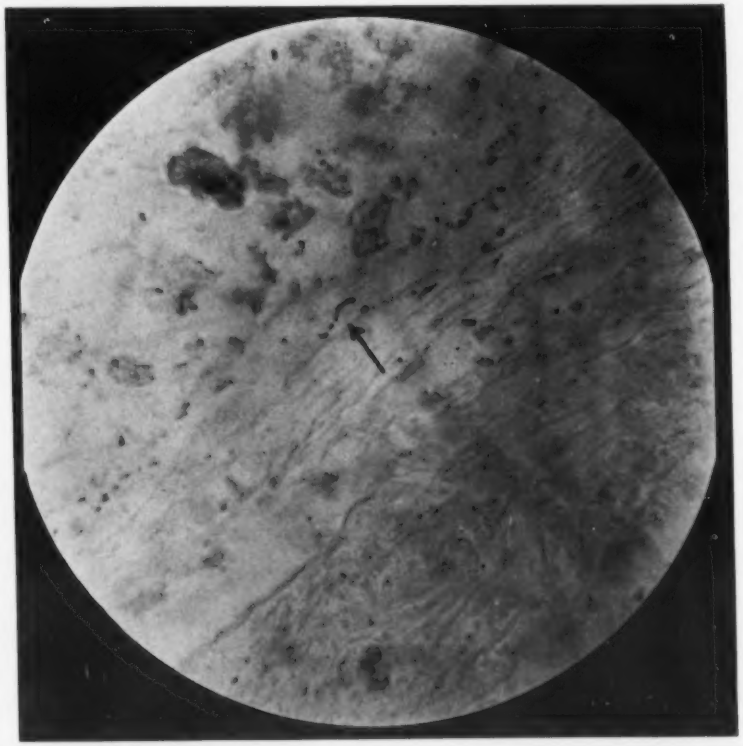

FIG. 28

Demonstration of streptococci in the interlobular connective tissue of liver.

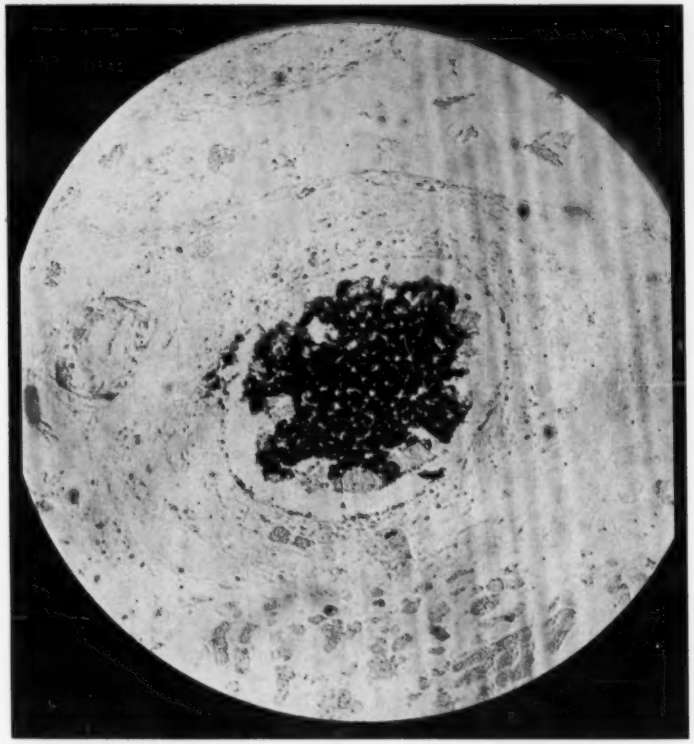

FIG. 29-A

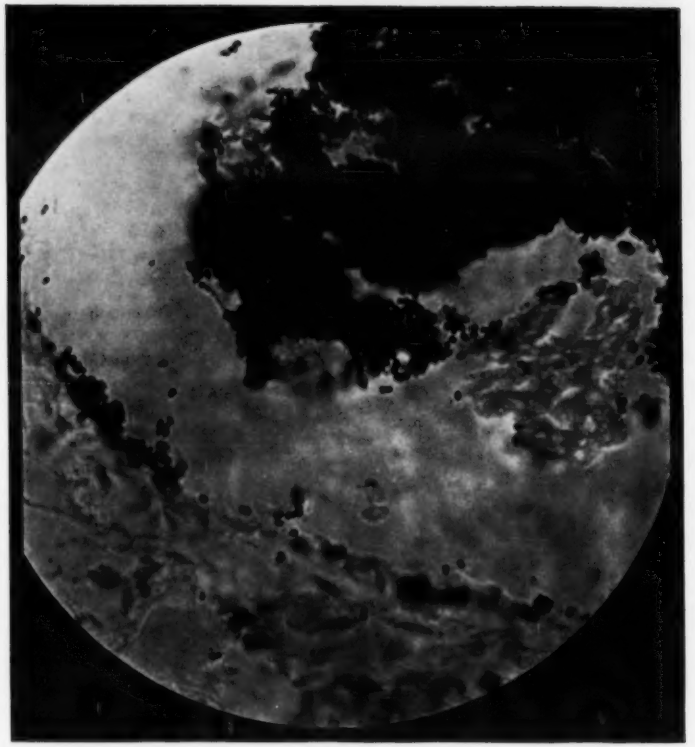

FIG. 29-B

Demonstration of streptococci in hepatic vessels.

Low-power magnification of a thrombus-like mass in a liver vessel, probably the portal vein.

Under high magnification (oil) the thrombus-like mass is made of a collection of bacteria, diplococci.

We think that during the period of artificial incubation, this bacterial mass originated from a diplococcus imbedded in the endothelial lining of the portal vein. We never encountered a similar picture in tissues that were not subjected to a previous culturing.

DISSEMINATION OF STREPTOCOCCI IN CARTILAGE

An avascular tissue such as cartilage should be among the least vulnerable to the direct effect of a hematogenous infection; consequently the toxic or allergic hypothesis of causation in arthritis should find definite test of its validity in the nature of cartilage pathology.

If it is possible for streptococci to invade cartilage in hematogenous infection, the nearest approach is from the periphery of this avascular tissue towards the center. The boundaries of an epiphyseal cartilage are the joint cavity, the epiphyseal cancellous bone, and the diaphyseal cancellous bone.

In dealing with the pathology we have already called attention to the inflamed pannus on the joint surface of cartilage. Under higher magnification, this pannus tissue is seen to be infiltrated with diplococci, similar in form to the streptococci which infiltrate the synovial membrane (Fig. 25).

The pathological changes in epiphyseal cartilage were described as a process of osteoblastic invasion of its matrix (Fig. 13). The buds of proliferating and highly vascular osteogenetic tissue invade the cartilage columns, destroy the cartilage cells, and simultaneously vascularize the invaded area, thereby carrying infection to it (Fig. 26-A). The high magnification of Figure 26-A shows streptococci in the invaded and partly destroyed cartilage cells. This infectious process may gradually involve a large part or the whole of the cartilage, and replace it by either bone or cancellous tissue as is shown in Figure 26-B.

SUMMARY AND CONCLUSIONS

By incubating the whole joint we were able to demonstrate these infecting organisms in practically all lesions associated with chronic atrophic arthropathies. Streptococci were found in every part of the synovial tissues where pathological changes could be detected. No streptococci could be demonstrated in compact bone, yet the spread of infection in bone tissue could be traced step by step through its medullary and haversian vascular supply. In the avascular cartilage the spread of streptococci was through infected bone tissue and synovial infiltration. Normal joints were subjected to the same procedure with uniformly negative findings.

To complete the picture of infection, we have recently studied the tendons and muscles in the immediate neighborhood of arthritic joints. We had no difficulty in demonstrating streptococci in tendons at the zone of nuclear proliferation (Fig. 27). Muscles were extensively infiltrated with streptococci at their sheaths, but in spite of great care the possibility of outside contamination in surface areas must be considered.

Throughout this study the progress of the disease could always be traced directly to the terminal blood vessels, as is true in all infections of hematogenous origin. Despite the specific selectivity of the arthrotropic streptococci used in these experiments, internal organs, especially

the liver and kidneys, were not exempt from pathological changes of toxic nature involving their parenchyma. Nevertheless, streptococci could be demonstrated in the interlobular connective tissue of the liver (Fig. 28), and occasionally even in the hepatic vessels (Figs. 29-A and 29-B). This finding is highly significant in that it forcibly brings home the fact that chronic rheumatoid arthritis is fundamentally a systemic disease, and it explains the transient septicaemias that occur intermittently in the course of the infection.

PATHOLOGICAL FRACTURES IN OSTEOMYELITIS*

BY NORMAN CAPENER, F.R.C.S., EXETER, ENGLAND
AND KENNETH C. PIERCE, M.D., ANN ARBOR, MICHIGAN

A series of pathological fractures in patients suffering from chronic osteomyelitis, seen by us at the University Hospital, has caused us to investigate the frequency, cause, prevention, and treatment of this quite serious complication. At first sight it appeared a somewhat commonplace subject, but we were surprised to find an extreme paucity of references to it in the literature. Most writers deal with it very cursorily and the following quotation is typical of many of the statements in textbooks: "Pathological fractures are not uncommon, especially if proper precautions are not taken". Desiring to know what these precautions should be and believing that the errors in treatment were probably of commission as well as omission, we have prepared the following report based upon a study of 1068 cases of osteomyelitis, seen in this Clinic during the past five years.

Almost all cases of pathological fracture in osteomyelitis are due to preventable causes. Delayed recognition of the disease or inadequate treatment in the early, acute stage are very important factors, for both may be responsible for massive diaphyseal sequestration. And here it may be stated that every case in which there is sequestration involving the whole circumference of the diaphysis of a long bone is essentially one of fracture, although none of the classical signs of fracture may be present because of the development of a supporting involucrum. From this fact it is obvious that pathological fracture is a complication of the chronic stage of osteomyelitis, except in certain cases of epiphyseal separa-

FIG. 1

Case 1. Massive sequestration of the lower third of the femoral shaft with fracture of the involucrum.

*From the Department of Surgery, University of Michigan.

tion due to an extensive acute metaphysitis, as seen, for example, at the upper end of the femur.

As secondary factors there are then: (a) excessively large diaphyseal separation, and (b) the formation of an involucrum that is inadequate to stand the normal stresses brought to bear upon the limb. In addition, fracture is facilitated by imperfect immobilization and support of the diseased bone and is, therefore, more commonly found in the single bones —the humerus and the femur—than in those that have a companion bone for support.

The above indicates diagnostic and therapeutic errors of omission. The most important error of commission is seen in the excessive zeal of the surgeon in the removal of large segments of the circumference of the shaft of the bone or of the supporting involucrum, and in his application of undue force to a structure incapable of standing even normal stresses.

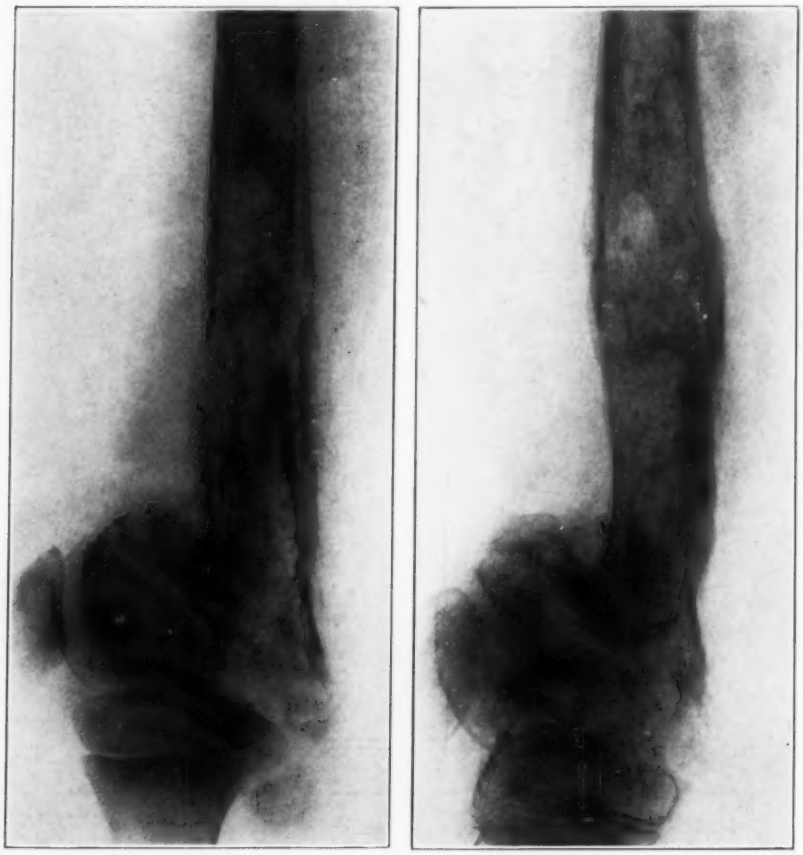

FIG. 2-A FIG. 2-B

Case 3. Metaphyseal fracture at the lower end of the femur. *A*. Before sequestrectomy. *B*. Solid union but poor position.

While error of judgment should undoubtedly be blamed, it is only fair to mention that one more important factor must be borne in mind. Long-standing atrophy of disuse, with the decalcification consequent upon prolonged hyperaemia, produces a soft spongy tissue that has a much greater fragility than normal bone.

It is beyond the scope of the present article to discuss any further the errors in diagnosis and early treatment already mentioned and which have been adequately dealt with by numerous other writers. We do believe, however, that a few remarks are desirable upon the surgical errors found in the operative treatment of late cases of osteomyelitis.

In the modern treatment of the disease attention has rightly been taken from the use of antiseptic solutions for the irrigation of cavities and stress laid on the complete opening up of these cavities to the surface and

FIG. 3-A FIG. 3-B

Case 10. Fracture through central abscess. *A*. On admission. *B*. On discharge with union.

to the removal of infected and necrotic material. To effect this, "guttering" and "saucerization" of lesions have been advocated, the cavities being allowed to become obliterated, partly as the result of the falling in to them of muscles and partly by the inward growth of granulation tissue with resultant scarring. This principle is undoubtedly correct, but where the attention of the surgeon has been directed to the production, by his operative treatment, of a shallow "saucer" rather than to a moderately deep "gutter", there danger has arisen. Overzealous removal of bone is then a great surgical error which is assisted in the formation of fractures by the use of unnecessary violence, especially that produced with the hammer and gouge and by inadequate splinting after operation.

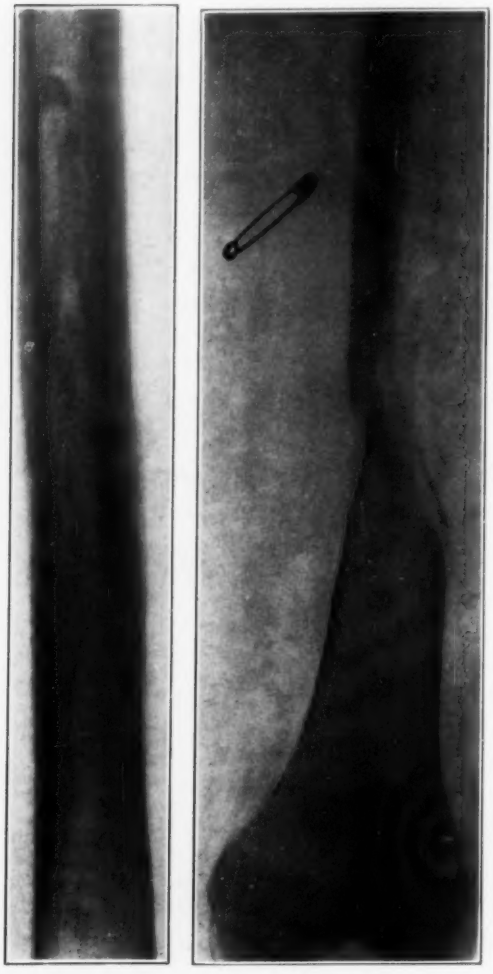

FIG. 4-A FIG. 4-B

Case 12. Chronic osteomyelitis with extensive central bone abscesses. *A*. Before treatment. *B*. After "saucerization"—fracture. An example of excessive operative removal of bone.

When removing a large sequestrum, its enveloping involucrum should be very carefully conserved. If a linear series of chisel cuts be made in the involucrum throughout the length of the sequestrum, the former may often be opened up sufficiently to allow the latter to be extracted.

The ability of bones, weakened by operation, to modify their shape and strength in response to the stimulus of function, in order adequately to bear the stresses brought to bear upon them, is remarkable. Assistance to this end should be given by graduated exercises with proper support. Bone production is of course dependent in part upon the calcium content of the surrounding tissues and Murray[1] has recently suggested the use in clean bone cavities of masses of calcium salt as an accessory to the development of new bone.

FIG. 5-A

FIG. 5-B

FIG. 5-C

Case 13. Multiple chronic bone abscesses. *A*. Before treatment. *B*. After "saucerization"—fracture. *C*. Lateral view after solid union has occurred. An example of excessive operative removal of bone.

FIG. 6

Case 14. Fracture of femur through "saucerized" area.

In extensive lesions of the long bones, fractures should be anticipated by treating them as such—immobilizing the joints above and below the lesion except for carefully supervised exercises. The most efficient splint available should be employed, and most often this will be found to be a mold of plaster-of-Paris in the earlier stages and, for the lower extremity, a caliper brace during convalescence.

In the tabulation of data relating to the eighteen patients with pathological fracture in the present series, it will be seen that there were thirteen patients with fracture of the femur, one of whom had a fracture of both femora and two of whom had refractures at the same site after a previous union. With two exceptions all these fractures of the femur were at or below the junction of the lower and middle thirds. There were three patients with fracture of the middle of the shaft of the humerus,—one of these had a refracture; another of these patients also had a pathological fracture of the clavicle. The remaining two patients had fractures of the

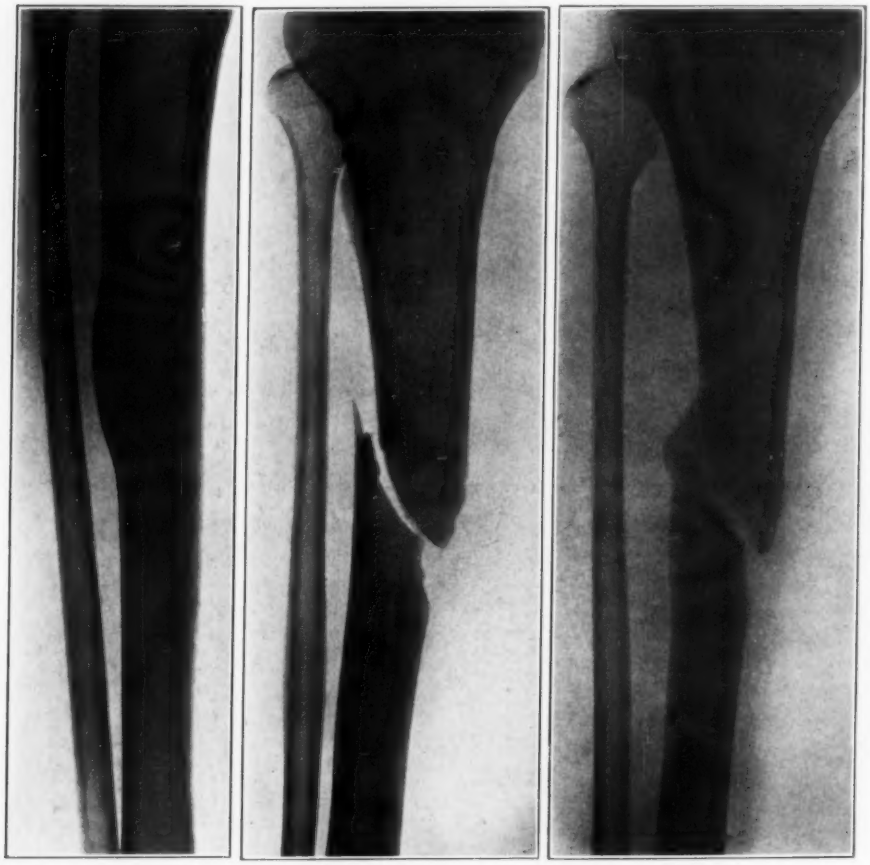

FIG. 7-A FIG. 7-B FIG. 7-C

Case 15. Single bone abscess of tibia. *A*. Before operation; bone sclerosis overshadows the abscess. *B*. After fracture. *C*. Partial union.

tibia and of the ulna respectively. Of the twenty-four fractures (including refractures) five occurred before operation, four at operation, and the remaining fifteen after operation.

TABLE I

Total number of patients with osteomyelitis, October 1925–March 1931	1086
Total number of pathological fractures of all kinds	54
Osteomyelitis of shaft of long bones	18
Osteomyelitis with separation of epiphysis secondary to septic arthritis	4
Neurotrophic lesions	12
Metastatic carcinoma	8
Alveolar abscess	2
Cyst	2
Old fracture	2
Sarcoma	1
Chondroma	1
Giant-cell tumor	1
Rickets	1
Tuberculosis	2
Percentage of pathological fractures in osteomyelitis	1.66 per cent.
Percentage of cases of osteomyelitis of shaft of long bones in total pathological fractures	33.33 per cent.

FIG. 8-A

FIG. 8-B

Case 17. Subtrochanteric bone abscess. *A*. After operation with fracture. *B*. Union (solid clinically).

TABLE II

No. of Case	*Sex*	*Age*	*Site of Fracture*	*Type of Lesion*	*Operation*	*Nature of Trauma*	*Time of Fracture*	*Result*
1	M	15	Femur, left (lower third).	Chronic with massive sequestration.	No operation.	Slight trauma.	Before admission.	Patient lost sight of.
2	M	33	Humerus, right (mid-shaft).	Sclerosing with acute exacerbation.	Saucerization.	During transfer to operating table.	At operation.	Weak, bony. Refractured 6 months later, non-union resulting.
3	M	11	Femora, right, intertrochanteric: left, supracondylar.	Subacute with massive sequestration.	No operation before fractures.	Indefinite trauma.	Before first admission.	Weak, bony union. Recent case.
4	F	14	Femur, right. Junction middle and lower thirds. Fractured three times.	Chronic with sequestration.	No operation before first fracture; saucerization 1 year before second fracture and again 3 months before third.	First fracture at age of 4 years. Second fracture while playing on floor without support; third fracture, leg dropped during dressing.	Second fracture 1 year after operation. Third fracture 3 months after operation.	There was non-union and patient died from pyaemia and secondary infection of wound with actinomyces.
5	M	14	Femur, left (lower third).	Chronic with massive sequestration.	Operation: sequestrectomy and saucerization.	Operative manipulation.	At operation.	Firm bony union.
6	M	13	Clavicle, left; humerus, left.	Chronic with massive sequestration, both bones.	Sequestrectomy and saucerization both bones.	Not recognized at time of fracture.	At operation (clavicle). Postoperative (humerus).	Union with total regeneration of clavicle. Solid union of humerus with no disability from either fracture.
7	M	16	Ulna, left (lower metaphysis).	Central abscess. No sequestration.	Saucerization.	Operative trauma.	At operation.	Perfect union. No disability.
8	M	21	Humerus, right.	Chronic with massive sequestration.	Sequestrectomy and saucerization.	Operative trauma.	At operation.	Weak, bony union but patient died 6 months later of pyaemia.
9	F	13	Femur, left (middle and lower third).	Sclerosing type.	Saucerization.	During changing of cast.	2 months after operation.	Non-union. Walking in caliper. Wound healed.

(*Continued on next page*)

TABLE II—*Continued*

No. of Case	*Sex*	*Age*	*Site of Fracture*	*Type of Lesion*	*Operation*	*Nature of Trauma*	*Time of Fracture*	*Result*
10	F	10	Femur, left (middle and lower third).	Chronic with massive sequestration.	No operation on bone prior to fracture.	Fell while walking with crutches.	Preoperative.	Solid union but with shortening of 2 inches.
11	M	14	Femur, left (junction middle and lower thirds).	Chronic sclerosing, multiple central abscesses.	Saucerization on three occasions.	Tripped on carpet through patient's carelessness.	5 months after last operation.	Delayed but strong union. Walks with caliper.
12	F	16	Femur, right (junction lower and middle thirds). (2 fractures.)	Chronic with multiple central abscesses. No sequestrum.	Saucerization.	Operative trauma. Refractured later in bed through patient's negligence.	Second fracture 6 months after operation.	Non-union. Died following erysipelas and wound diphtheria.
13	M	32	Femur, right.	Chronic osteomyelitis with central abscesses.	Saucerization.	Struggled during dressing under general anaesthesia.	4 days after operation.	Solid union. Walks without support.
14	F	29	Femur, left (junction middle and lower thirds). (2 fractures.)	Chronic osteomyelitis with central abscesses.	Saucerization.	Jumped out of bed in fright.	First fracture 6 months after operation. Refractured at operation here.	Malunion with shortening. Still under treatment.
15	M	24	Tibia, left (middle third).	Chronic central diaphyseal abscess.	Saucerization.	Sudden twist upon leg. Violence sufficient to fracture normal tibia.	6 weeks after operation.	Delayed but solid union.
16	M	10	Femur, left (junction middle and lower thirds).	Acute osteomyelitis.	Incision and drainage of subperiosteal abscess, and medulla.	Blow on uncovered but supported thigh.	8 weeks after operation.	Solid union. Walks without support.
17	M	41	Femur, left (subtrochanteric).	Chronic central abscess.	Small window drainage of abscess.	Slipped and fell while walking with crutches. No other support.	3 weeks after operation.	Delayed, solid union; walks with caliper. Recent case.
18	M	17	Femur, left (supracondylar).	Subacute osteomyelitis.	Saucerization.	No definite trauma; discovered during dressing; limb in long leg cast.	5 days after operation.	Amputation on account of non-union and virulent infection of knee joint.

SUMMARY

1. Pathological fracture in cases of osteomyelitis of the shafts of long bones has occurred in one and two-thirds per cent. of a total of 1086 cases. Osteomyelitis has been responsible in this clinic for thirty-three and one-third per cent. of all pathological fractures in long bones.
2. Correct diagnosis and proper treatment at the earliest stage of the disease is obviously the most important prophylactic measure.
3. Every case with massive sequestration must be regarded as a fracture before abnormal mobility or deformity is evident.
4. A deep gutter rather than a shallow saucer is a safer mechanical means of dealing with central bone abscesses. In the removal of sequestra the involucrum should be conserved.
5. Careful attention should be paid to the proper provision of splints or other support during convalescence.

The writers wish to acknowledge their indebtedness to Dr. Frederick A. Coller, Director of the Department of Surgery, University of Michigan, who has given valuable assistance in the conduct of this inquiry.

REFERENCE

1. Murray, Clay Ray: Delayed and Non-Union in Fractures in the Adult. Ann. Surg., XCIII, 961, May 1931.

SPONDYLOLISTHESIS AND VERTEBRAL ANOMALIES IN SKELETONS OF AMERICAN ABORIGINES. WITH CLINICAL NOTES ON SPONDYLOLISTHESIS*

BY RUSSELL T. CONGDON, M.D., F.A.C.S., WENATCHEE, WASHINGTON

I. VERTEBRAL ANOMALIES IN SKELETONS OF AMERICAN ABORIGINES

In the pursuit of archeological explorations, the writer has had the good fortune to discover several skeletons in which there was a spondylolisthesis. In each case the spondylolisthesis was accompanied by a bilateral separation of the neural arch. The etiological relationship of the defect in the vertebral arch to the spondylolisthesis present was strikingly suggested.

FIG. 1

Anatomical Specimen 27. Spondylolisthesis of fifth lumbar vertebra with bilateral separation of the neural arch. The posterior separated portion of the neural arch (*A*) is mounted in a posterior position to better show its outline.

FIG. 2

Anatomical Specimen 38. Spondylolisthesis of fourth and fifth lumbar vertebrae. Bilateral separation of arches of both fourth and fifth lumbar vertebrae. There is marked bone excrescence about both articulations, more pronounced at the lumbosacral articulation.

*Submitted for publication August 1, 1931.

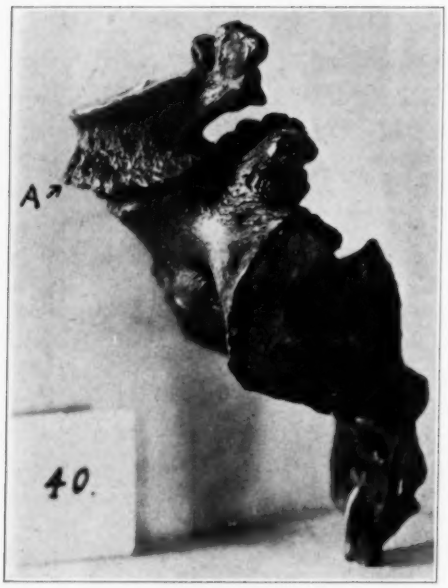

FIG. 3

Anatomical Specimen 40. Spondylolisthesis of fifth lumbar vertebra, accompanying bilateral separation of the neural arches of the fifth lumbar and first sacral vertebrae. A flaring ridge of excrescent bone encircles the lower third of the body of the fifth lumbar vertebra (*A*). The posterior separated portions of the arch are not shown.

FIG. 4

Anatomical Specimen 42. Bilateral separation of neural arch of fifth lumbar vertebra with spondylolisthesis. A heavy, shelving ridge of bone projects out beneath the fifth lumbar from the anterior surface of the first sacral segment (*A*).

B. The separated, posterior portion of the neural arch.

In view of the interest shown at the present time in vertebral defects and variations in the lumbosacral articulation, and their clinical bearing, a description of these specimens is presented. A roentgenographic study of the specimens was made and the findings correlated with the roentgenographic findings in the writer's clinical cases of spondylolisthesis. Certain deductions from this study are offered for consideration.

The anatomical material on which this study is based comprises nearly two hundred skeletal remains of American aborigines, obtained in the course of archeological investigations in the Columbia River region.

Bilateral separation of the neural arch was found in ten subjects. This occurred in the fifth lumbar vertebra in nine subjects, in the fourth lumbar in one; in one of the nine subjects, the bilateral defect occurred in both the fourth and the fifth lumbar vertebrae.

Striking changes in the bone structure of the vertebral body are present in these defective vertebrae. There are, also, marked changes in the structure of the first sacral body, related to the structural changes in the accompanying defective fifth lumbar. These changes are limited to the articulation between the defective fifth lumbar vertebra and the sacrum. They do not involve the remaining intervertebral articulations,

except in the two cases in which the separation of the arch occurs in the fourth lumbar. These changes in bone contour are so marked in many of the specimens that it is possible to reconstruct,—that is, to place the defective vertebra on the upper surface of the sacrum in the position which it occupied during the latter part of the life of the individual. In five of the subjects in which this has been done, there is apparent a definite spondylolisthesis (Figs. 1, 2, 3, and 4).

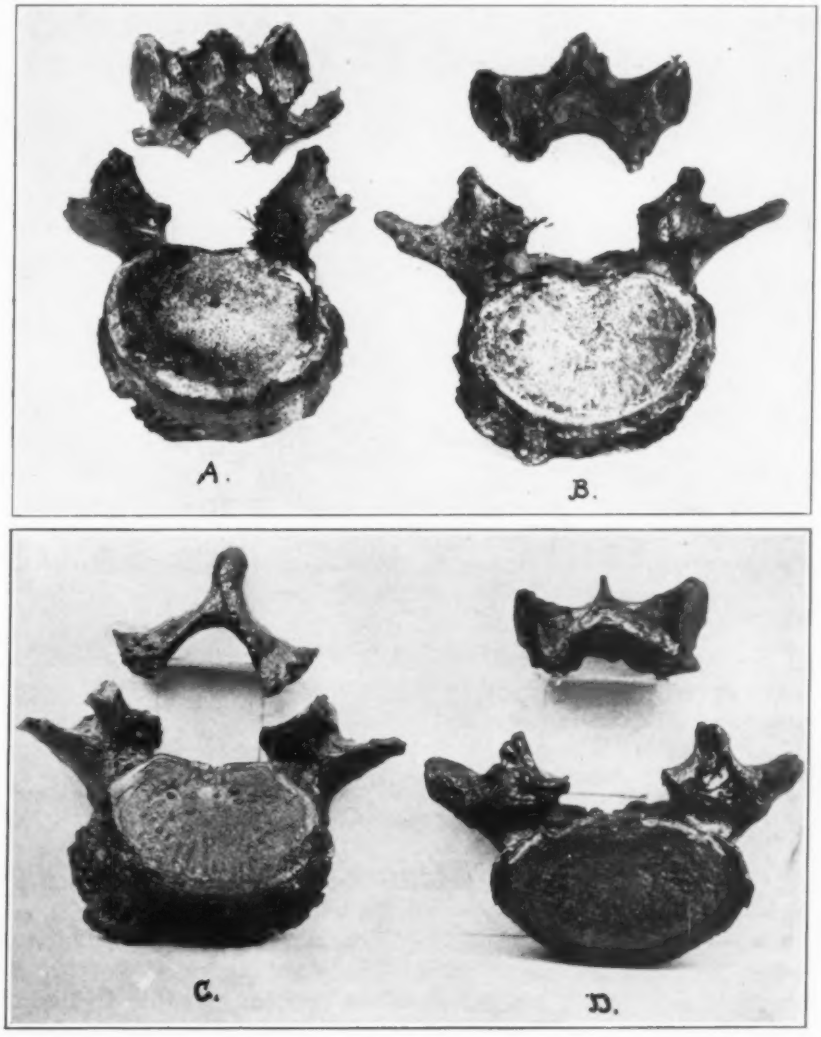

FIG. 5

Bilateral separation of the neural arch.
A. Fourth lumbar vertebra.
B. Fifth lumbar vertebra of Anatomical Specimen 38 (Fig. 2).
C. Fifth lumbar vertebra of Anatomical Specimen 42 (Fig. 4). Pronounced collar of excrescent bone accompanying the spondylolisthesis.
D. Specimen 60, fifth lumbar.

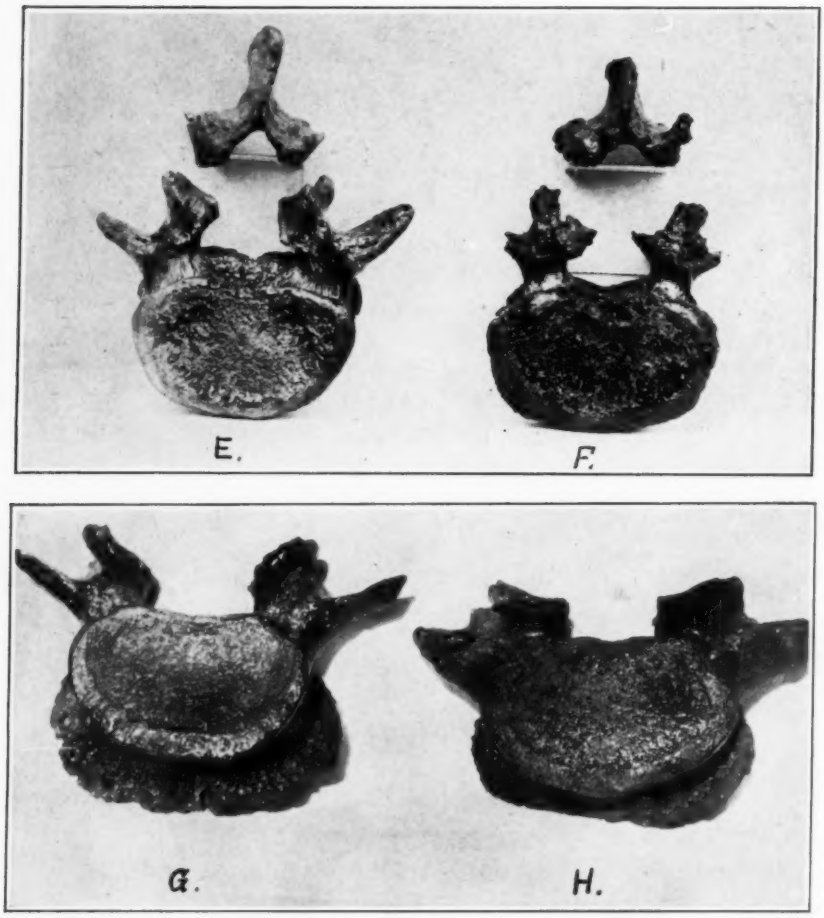

FIG. 6

Bilateral separation of neural arch.
E. Anatomical Specimen 41, fifth lumbar.
F. Anatomical Specimen 47, fourth lumbar.
G. Fifth lumbar vertebra of Anatomical Specimen 40 (Fig. 3).
H. Anatomical Specimen 44, fifth lumbar vertebra. The flaring lip of excrescent bone is well marked in the latter two spondylolisthetic vertebrae.

Examination of the vertebrae, in which bilateral separation of the arch is present, shows that the separation has occurred at a point where the laminae join the pedicles,—that is, between the superior and inferior articular facets (Figs. 5, 6, and 8). The vertebra, then, is divided into two entirely separate parts,—the body, with the pedicles, transverse processes, and superior articular processes, constituting the anterior portion; while the laminae, spinous process, and inferior articular processes comprise the posterior portion. The posterior portion, then, bearing the inferior articular facets, is devoid of any bony attachment to the body of the vertebra.

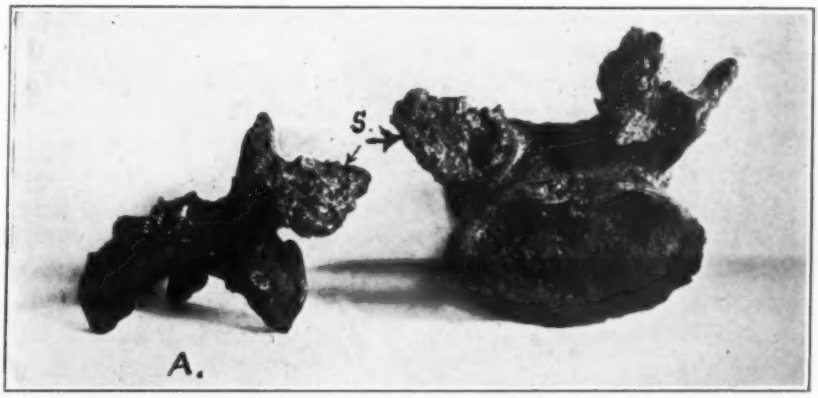

FIG. 7

Fifth lumbar vertebra of Specimen 27. Bilateral separation of the neural arch. Here, the plane of separation on the left side varies from the usual interarticular position. It extends through the pedicle. *A* is the posterior part of the arch. The rough, pitted surfaces, resembling an epiphyseal surface, are shown at *S*.

In one of the vertebrae there is a variation in the position of the defect. In this specimen (Fig. 7) the plane of non-fusion on the left side extends obliquely through the pedicle and transverse process, leaving the left superior articular, as well as inferior articular, process as part of the posterior portion of the defective vertebra.

The articular processes of these defective vertebrae are well formed and the facets are normal. The inferior facets conform in size and shape to the corresponding superior facets of the segment below, with which they articulate. The spinous processes are well formed; none are bifid.

The instability of the spine, resulting from this laminar defect, is clearly portrayed by these specimens. Deprived of the holding power of the inferior articular processes, the position of the vertebral body was

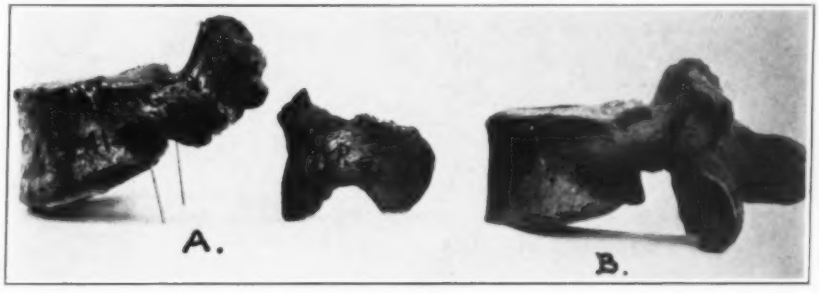

FIG. 8

A. Specimen 41. Bilateral separation of neural arch, fifth lumbar vertebra. The laminar defect is seen to be situated between the superior and inferior articular processes. The inferior articular processes, therefore, are a part of the posterior, separated portion of the arch. With this "anchor" separated, the vertebral body is deprived of its main holding structures; the stability of the articulation is greatly diminished.
B. Normal fifth lumbar for comparison.

maintained by ligaments. These were subjected to a stress far greater than they are normally called upon to meet.

That the ligaments alone were unable to maintain the fifth lumbar body in normal position under these conditions is clearly shown in a large percentage of the specimens in the writer's collection, in which there is bilateral separation of the arch. Placing the body of the defective fifth lumbar vertebra on the superior surface of the sacrum of the same subject, it is apparent from the molded shapes of the opposing surfaces that the body has moved forward and downward on the sacrum (Figs. 1 and 4). The extent of forward displacement varies in five of the specimens from one-third to one-half of an inch. Accompanying this spondylolisthesis there are marked bony changes. The anterior margin of the first sacral segment is rounded off or beveled (Fig. 9). Most striking, however, is the flaring, collar-like ridge of excrescent bone (Fig. 4, *A*), formed on the anterior surface and lateral margins of the first sacral segment, beneath the overhanging portion of the fifth lumbar body. A similar collar of excrescent bone encircles the body of the defective fifth lumbar vertebra a little distance above its lower margin (Figs. 2 and 3). This hypertrophic arthritis is limited to the articulation of the fifth lumbar with the sacrum. In Specimen 38 (Fig. 2) both the fourth and fifth lumbar vertebrae show bilateral separation of the neural arch. There is marked hypertrophic arthritis at both the articulation of the fourth and fifth lumbar vertebrae and the lumbosacral articulation, but none at the other vertebral articulations.

This hypertrophic arthritis, localized at the inferior articulations of those vertebrae which have defective separated neural arches, is uniformly present. It is a reaction to strain, and may reasonably be interpreted as evidence of the instability of the articulation.

The defect in the arch, as previously stated, occurs through the laminae between the superior and inferior facets. This is its situation in ten of the eleven specimens in the author's collection. The variation from this common form is shown in Figure 7. Close examination of these vertebrae reveals two facts which have a bearing on the nature of the defect: First, the surface of the bone at the point of non-fusion of the arch is roughly pitted and irregular (Fig. 7, *S*). This closely resembles the appearance of an epiphyseal surface. Second, although there are slight variations in the position and pattern of the bone surfaces of the defects, on comparison of one vertebra with another, there is a striking similarity between the defects on either side of the same vertebra. This similarity of the defects in the two sides of the arch of the same vertebra is interpreted by the writer as evidence of a developmental origin. Were the separations of the arch due to fracture, it is far more likely that the lines of fracture through the laminae would differ considerably on the two sides, because of variation in the direction of application of the force producing the fracture. In Specimen 40 (Fig. 3) there is bilateral separation of the neural arch of the first sacral as well as of the fifth lumbar vertebra. The

possibility of fracture of the laminae can be eliminated with certainty in the first sacral arch, since the body and pedicles of this segment are an integral part of the sacrum and sheering strain could not take place. The defects in these two segments present the same appearance. To hold that the separation in the one case were due to a developmental defect and in the other to fracture would hardly be logical. These observations are in accord with the generally accepted theory that the cleft in the arches is due to a congenital anomaly in the bone nucleus formation, with imperfect ossification of the laminae.[1]

This defect, bilateral separation of the neural arch, probably occurs more frequently than is generally recognized. In the writer's material it was present in ten subjects out of 200, or five per cent. This approaches closely the figures of Willis,[2] who found it present in four and eight-tenths per cent. of 850 skeletons examined by him.

ROENTGENOGRAPHIC STUDY

A roentgenographic examination was made of several of the archeological specimens in the writer's collection, with the following results.

FIG. 9

Lateral roentgenograms of Specimen 27, shown in Fig. 1. Spondylolisthesis with bilateral separation of the neural arch.

A. With the anterior and posterior parts of the divided neural arch approximated, the defect is scarcely discernible.

B. With the vertebral body placed in its position of spondylolisthesis, the defect is clearly seen. Laminar defect indicated by arrow, *A*.

When the defective fifth lumbar vertebra is placed in approximately its normal position on the upper surface of the sacrum, and the posterior portion of the non-fused arch is approximated to the anterior portion, the defect is not definitely shown by the roentgenograms. In the lateral view there may be shown an indistinct line or thinning out at the site of the separation (Fig. 9). In the living subject, this would be entirely obscured by the overlying ilia and soft tissues. When, however, the body of the defective vertebra is moved anteriorly one-third to one-half of an inch, corresponding to its position in spondylolisthesis, the posterior portion of the arch remaining in normal position with its facets articulated with the sacral facets, lateral roentgenograms of the anatomical specimens show clearly the defect or separation (Figs. 9 and 10). In the living subject, because of the deep-lying position of the fifth lumbar, it is improbable that this defect could be demonstrated except in the presence of a considerable separation of the two portions of the arch, such as would exist in a more pronounced condition of spondylolisthesis.

Examination of the roentgenograms of the anatomical specimens shows

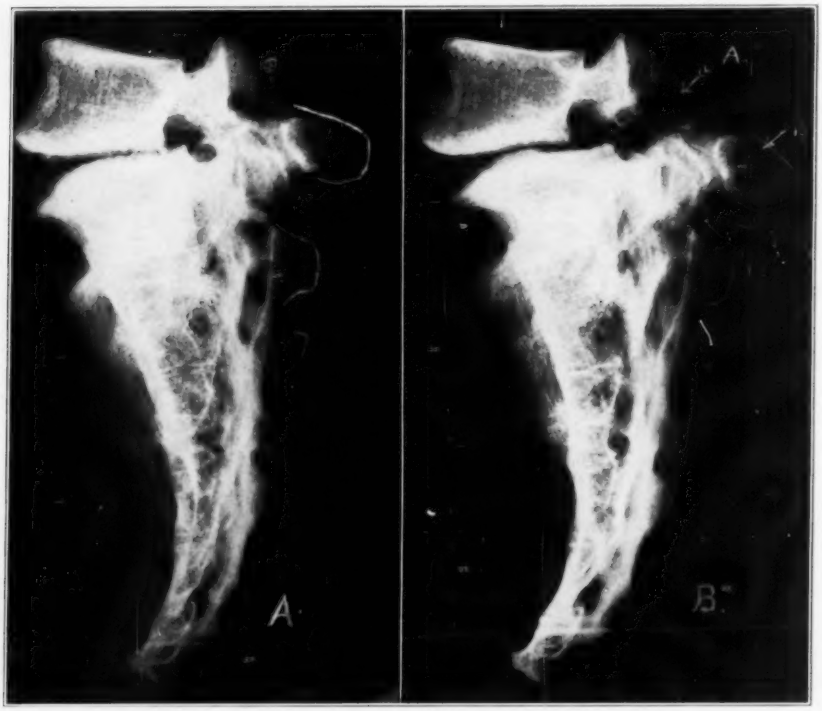

FIG. 10

Lateral roentgenograms of Specimen 42 shown in Fig. 4.

A. Defect not definitely shown when the two parts of the divided vertebral arch are approximated.

B. With the lumbar body in its position of spondylolisthesis, the laminar defect is clearly demonstrated. Defect at *A*. *B* shows spinous process and posterior portion of separated neural arch. (See Fig. 4.)

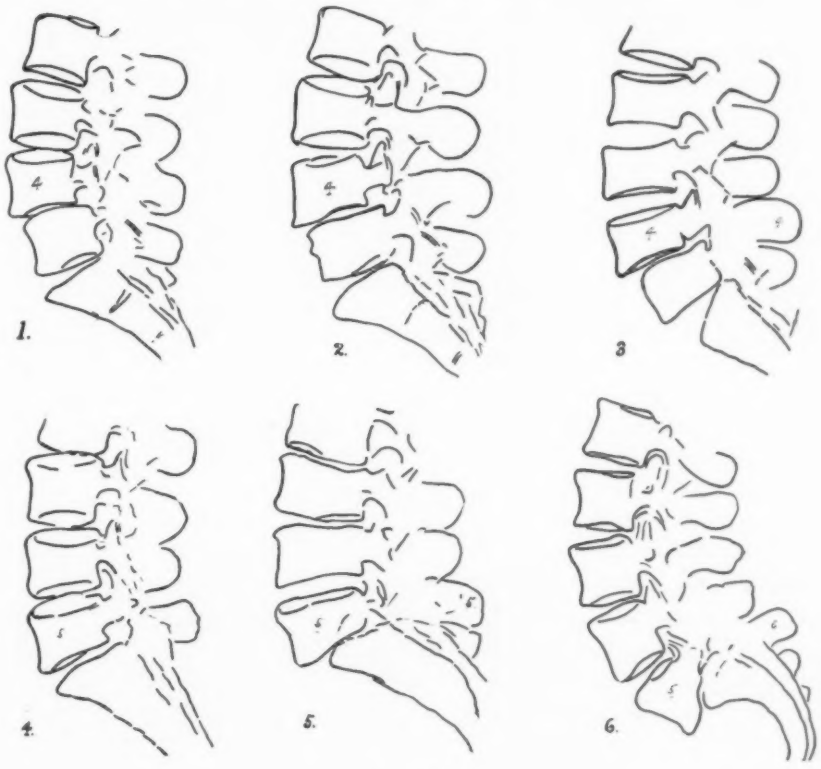

FIG. 11

Roentgen-ray tracings of patients. *1*, Case 1; *2*, Case 1 two years later. *3*, Case 2, anterior displacement of fourth lumbar vertebra. Tracings *4*, *5*, and *6* are of cases 3, 4, and 5, respectively. Spondylolisthesis of fifth lumbar.

In each case the spinous process has remained in its normal or posterior position, while the body of the vertebra and the anterior portion of the neural arch have been displaced anteriorly. The anteroposterior diameter of the vertebra involved, in each case, is seen to be increased in accordance with the amount of forward displacement of the body of the vertebra.

that the anteroposterior diameter, or measurement from the anterior border of the body to the posterior margin or tip of the spinous process of the vertebra, is increased according to the amount of forward displacement of the body (Figs. 9 and 10).

II. CLINICAL OBSERVATIONS

With these facts in regard to the roentgenographic appearance of the anatomical specimens in mind, the writer reviewed his clinical cases of spondylolisthesis (not Indian). A careful study of the roentgenograms was made in an effort to determine whether or not an associated vertebral defect could be demonstrated.

In only one of the five patients could a defect in the neural arch be definitely visualized, Case 3 (Fig. 14). Although the bilateral defect may

not be visualized in the roentgenogram, its presence may nevertheless be determined indirectly.

In our study of the anatomical specimens (Indian) of spondylolisthesis with bilateral laminar defects, it was observed that the anteroposterior diameter of the vertebra involved was increased.

The same observation was made on examination of the lateral roentgenograms of the clinical cases. In each case the anteroposterior diameter of the vertebra involved in the spondylolisthesis is greater than that of the other lumbar vertebrae. The amount of increase corresponds to the extent of forward displacement of the body. This detail is lost in the reproductions of the roentgenograms, but is clearly shown in the tracings (Fig. 11).

This increase in the anteroposterior measurement of the vertebra necessarily means that the vertebral body has moved forward, while the posterior portion of the neural arch has remained in the position which it occupied before the spondylolisthesis developed. It is, therefore, evidence of a separation or break in continuity of the neural arch.

Bowman and Goin [3] state that rarely, if ever, can this condition be recognized by means of roentgenographic examination. Sutherland [4] reported on a study of developmental anomalies of the spine. Roentgenographic examination of the lumbar spine and sacrum was made in approximately 12,000 of a consecutive series of 60,000 patients at The Mayo Clinic. He makes no mention of the observation of bilateral separation of the arch, while spina bifida occulta, involving the fifth lumbar, was found in one and three-tenths per cent. of the cases. In contrast to this, Willis, in his anatomical study, found spina bifida occulta in one and two-tenths per cent. of the specimens examined, while the bilateral defect in the arch was present in four and eight-tenths per cent. This study would indicate, then, not the rare occurrence of this defect, but that the existence of the defect cannot generally be demonstrated by roentgenography.

In view of this difficulty in detecting the presence of a bilateral separation of the arch, we believe that this observation, that there is an increase in the anteroposterior diameter of the vertebra involved in spondylolisthesis, is an important aid in determining the presence of a bilateral defect in the arch.

Study of the anatomical specimens of spondylolisthesis, and examination of the roentgenograms of the writer's cases of spondylolisthesis, then, would indicate strongly that in the development of spondylolisthesis the posterior portion of the neural arch remains in its normal position, retained by the inferior articular processes and by the powerful interspinous ligaments, while the vertebral body, with the pedicles and superior articular and transverse processes, slides forward and downward.

Any operative procedure, undertaken to stabilize the lumbar and lumbosacral region for the relief of symptoms resulting from spondylolisthesis, should be based on an understanding of the underlying pathol-

FIG. 12

Case 1. Lateral view. Spondylolisthesis of fourth lumbar vertebra. Ridge of excrescent bone indicated by arrow, same as Tracing *2*, Fig. 11.

FIG. 13

Case 2. Lateral view. Spondylolisthesis of fourth lumbar vertebra. Same as Tracing *3*, Fig. 11.

FIG. 14

Case 3. Lateral view. Spondylolisthesis of fifth lumbar vertebra. Laminar defect indicated by arrow. Corresponds to Tracing *4*.

ogy. In the presence of a bilateral separation of the neural arch, the insertion of a single bone graft into the split spinous processes, extending above and below the lumbosacral articulation, will not accomplish the purpose intended. It should be borne in mind that the separation of the neural arch occurs in the fourth lumbar in a definite percentage of the cases. The fixation should then include the second and third lumbar vertebrae above and extend well down on the dorsum of the sacrum. A modified Hibbs fusion with the addition of tibial grafts, one placed on either side of the spinous processes, as carried out by Myerding,[5] offers a most satisfactory method of stabilizing the defective lumbosacral and lower lumbar articulations.

CASE REPORTS

CASE 1. Male, aged forty-four. "Hip trouble" had been present for more than a year, with pain in right thigh aggravated by walking, relieved by lying down. Symptoms began six weeks after a fall, when he alighted in a sitting position, got up and walked, experiencing no symptoms of injury.

Lateral roentgenograms showed spondylolisthesis of the fourth lumbar (Fig. 11, Tracing *1*). Fusion operation was advised, but refused.

When reexamined two years later, there was marked improvement in symptoms. Lateral roentgenogram shows about the same degree of spondylolisthesis. A ridge of excrescent bone had formed on the anterior border of the fifth lumbar (Fig. 11, Tracing *2*, and Fig. 12).

CASE 2. Male, aged forty-six. Received a severe back injury a year ago, when thrown against the wheel of a steam shovel. Examination showed a rigid lumbar spine. There was a prominence of the fourth lumbar spinous process with depression above, and angulation in the mid-dorsal region with deviation to the left.

X-ray examination: The anteroposterior view shows a compression fracture of the sixth dorsal vertebra. The lateral roentgenogram shows spondylolisthesis of the fourth lumbar (Fig. 13). The anteroposterior diameter of the vertebra is increased, indicating separation or fracture of the arch (Fig. 11, Tracing *3*).

CASE 3. Male, aged thirty-two. Had had pain in left hip and sciatic region for five years. One year before onset, he sat down hard, dropping a distance of three feet. Examination showed a tilting of the pelvis. The spinous process of the fifth lumbar was prominent, with a depression above.

X-ray examination: Lateral roentgenogram shows spondylolisthesis of the fifth lumbar vertebra. A laminar defect is visualized (Fig. 11, Tracing *4*, and roentgenogram, Fig. 14).

It is improbable that the injury in this case could have produced a fracture of the lamina. In the presence of a bilateral laminar defect, however, it is quite possible that a separation of the cartilaginous junction of the arch may have resulted.

CASE 4. Male, aged fifty-five, rancher. Gave a history of pain and burning sensation in lower back and legs for ten years; relief on lying down; severe pain on jarring. Examination showed the lumbar spine held rigidly, the normal curvature obliterated. There was a prominence of the fifth lumbar spinous process. X-ray examination shows extensive spondylolisthesis of the fifth lumbar vertebra. The spinous process has remained in its normal position on the dorsum of the sacrum. The anteroposterior measurement of the fifth lumbar is correspondingly increased (Fig. 11, Tracing *5*, and Fig. 15).

FIG. 15

Case 4. Lateral view. Spondylolisthesis of fifth lumbar vertebra. Corresponds to Tracing *5*.

FIG. 16

Case 5. Lateral view. Advanced spondylolisthesis of fifth lumbar vertebra. Same as Tracing *6*.

FIG. 17

Case 5. Anteroposterior view. Body of fifth lumbar vertebra hanging well below the top of sacrum.

CASE 5. Male, forty-two years of age. There was no history of injury. Patient complained of pain in the sacro-iliac region, and urinary frequency for two years. On examination there was apparent a marked depression over the region of the lower lumbar spinous processes with a prominence below. Roentgenographic examination confirmed the diagnosis of spondylolisthesis (Fig. 11, Tracing *6*, and Figs. 16 and 17).

Of the writer's cases, two patients gave a history of definite severe trauma, and one had suffered a slight injury, while in the remaining two the onset was gradual with no history of definite injury.

The history of trauma should be carefully scrutinized. When spondylolisthesis develops gradually or following an injury of moderate severity—such as lifting a heavy weight—one is justified in considering that there was probably an underlying vertebral defect with resultant instability of the articulation.

SUMMARY

Bilateral separation of the neural arch was found in five per cent. of 200 skeletons examined.

Spondylolisthesis was present as an associated lesion in nearly fifty per cent. of the subjects having bilateral separation of the neural arch. The existence of this defect in the arch cannot generally be demonstrated, roentgenologically, in the living subject. When, however, spondylolisthesis is present and there is a considerable space between the two parts of the divided arch, the defect may be visualized. Its existence is suggested when the anteroposterior diameter of the vertebra involved in spondylolisthesis is greater than that of the other lumbar vertebrae, as seen in the lateral roentgenogram.

Bilateral separation of the arch results in a marked instability of the lumbar spine.

Increasing knowledge, gained from roentgenographic examination and operative findings, indicates that this defect is the fundamental etiological factor in a rather large group of cases of spondylolisthesis.

BIBLIOGRAPHY

1. NEUGEBAUER, F.: *Quoted from* The Vertebrae. Annals of Roentgenology, Vol. VIII. By A. W. George and R. D. Leonard. New York, Paul B. Hoeber, Inc., 1929.
2. WILLIS, T. A.: The Lumbo-sacral Vertebral Column in Man. Its Stability of Form and Function. Am. J. Anat. XXXII, 95, 1924.
3. BOWMAN, W. B., and GOIN, L. S.: Traumatic Lesions of the Spine. Am. J. Roentgenol. XVI, 111, Aug. 1926.
4. SUTHERLAND, C. G.: A Roentgenographic Study of Developmental Anomalies of the Spine. J. Radiology, III, 357, 1922.
5. MEYERDING, H. W.: Spondylolisthesis. J. Bone and Joint Surg., XIII, 39, Jan. 1931.

OPERATIVE FUSION OF THE UNSTABLE OR FLAIL KNEE DUE TO ANTERIOR POLIOMYELITIS

A Study of the Late Results*

BY MATHER CLEVELAND, M.D., NEW YORK, N. Y.

HISTORICAL SURVEY

The first recorded case of fusion or arthrodesis of an unstable knee in a patient suffering from residual anterior poliomyelitis is attributed to Prof. Albert. Vulpius[28] stated that "this ingenious operation is associated with the name of Albert who first performed it on July 10, 1878, on a girl of fifteen with paralytic flail knee. Various other experiments to the same end had been made, as, for instance, the ignipuncture and injections. L. Bauer of New York had undertaken the resection of an unstable genu valgum after traumatic separation of the epiphysis, and Szymanowski and Braatz, the stiffening of a joint. It was Albert, however, who placed the operation on a systematic basis and applied it to the knee, ankle, elbow, and shoulder."

In 1885 von Winiwarter[29] demonstrated the specimen of a knee joint of a boy on whom arthrodesis had been performed. Zinsmeister[30], in 1887, reported four cases of Prof. Albert's and one of his own. S. Smith[22], in 1889, reported that he had arthrodesed the knee of a boy of ten and considered the result successful. Dollinger[5], in 1891, added two cases of his own and considered them fairly successful. Hofmokl[13], Kummer[16], and Beck[1] each reported a case between 1892 and 1896. Beck stated he had done similar operations subsequently. In 1900 Propper[21] reviewed the earlier cases of Albert *et al.* and added a case of his own.

The next ten years were rather silent on this operative procedure, although a great deal was written about the stabilization of other joints of the lower extremity. The tendon transplants were becoming increasingly popular. Bradford[4] reported one successful case in 1901. Gwynne[9] cited the case of a boy on whom he had arthrodesed both knee and ankle joints successfully. Jones[14] wrote that he had a number of poor people who trudged about without serious inconvenience with knee and ankle stiff. He felt that the procedure might be preferred by those who could not afford braces or were situated at long distances from a brace-maker. He condemned the procedure in children. Vulpius[28], in 1908, recommended knee fusion and stated that firm ankylosis should be obtained in seventy-five per cent. of the cases. Writing later, he stated that the procedure had declined in popularity but he still felt that it had much to recommend it.

In 1910 Hibbs[12] reported a new operative procedure for stiffening the

* From the Clinic of the New York Orthopaedic Dispensary and Hospital.

unstable knee joint. His paper gave the details of the technique of mortising the patella into the denuded ends of the femur and tibia and suturing the periosteum of the patella over the front of the erased joint. In this report were included ten cases, the earliest done in January 1909.

Nathan[19], in 1914, wrote commenting unfavorably upon the procedure, but mentioned no cases that he had done. Frauenthal and Manning[6] in 1914 also wrote that "surgical stiffening of a joint has proved to be of most value for certain conditions of the ankle joint and must often be utilized for the flail knee". Soutter[24], in 1917, described a technique for arthrodesis of the knee joint. Lovett[17] in 1916 and 1917 stated that arthrodesis at the knee was not an operation to be lightly undertaken, because, to secure ankylosis in children, so much cartilage had to be removed that it might interfere with growth of the leg, and in adults it furnished a stiff knee which was awkward and unhandy. He felt that most people preferred a brace, and therefore considered that the operation should be discouraged. At a later date he wrote extensively on the operative treatment of the paralyzed leg, ignoring the flail knee.

Since 1920 Hallopeau[10], Hass[11], Kajon[15], Boorstein[2], Bossi[3], and Sorrel[23] have each reported one or two successful cases of arthrodesis of the flail knee. Orr[20], Stoffel[25], and Todd[27] have commented on the procedure, the latter considering it of doubtful value. In 1924 Thomson[26] reported four patients on whom he had done arthrodesis of a flail knee. He considered the results encouraging. Miller[18] in 1927 reported a series of twenty-five cases upon whom he had performed the Hibbs operation. These patients, ranging from nine to sixteen years of age, were greatly benefited in his opinion. Gray[7], in 1928, described the results in seven cases in which he had arthrodesed the knee joint. All of these patients were ten years of age or under. He stated that both parents and children were pleased with the result and he felt that the procedure should have a definite place in the surgery of infantile paralysis, provided bony union could be achieved with certainty. Guildal[8], in 1928, reported nineteen successful cases of arthrodesis of the flail knee joint.

From the earliest recorded case of arthrodesis of the flail knee in 1878 until 1920 there were reported a scant thirty odd cases. Those surgeons advocating the procedure were on the defensive, while many of their colleagues denounced it in no uncertain terms. Since 1920 sixty-three cases, exclusive of this study, have been reported in the literature. The operation seems to have gained slowly but surely a definitely deserved place in the operative treatment of the residual paralyses of anterior poliomyelitis. Much of the dissatisfaction with this operation has probably been due to inability to obtain bony fusion. The earlier procedures were doubtless resections of the knee joint, which may have destroyed the epiphyseal lines in children and seriously interfered with growth of the leg. The operative technique employed in this series of cases obviates both these objections as will be shown.

REVIEW OF CASES

From the first case done at the New York Orthopaedic Hospital in 1909 until the end of 1927, a period of nineteen years, 154 operative fusions of the knee joint have been performed in cases of anterior poliomyelitis with an unstable or flail knee. It has been possible to follow and examine carefully during the past two years ninety of these patients in an effort to evaluate this operative procedure. Of the ten original cases reported by Hibbs in 1910, five have been followed and are embodied in this report.

Preoperative Physical Examination showed:

I. Eighteen patients with one lower extremity involved.
II. Five patients with one or two upper and one lower extremity involved.
III. Forty-six patients with both lower extremities involved.
IV. Eleven patients with both lower extremities involved, one of these very slightly.
V. Ten patients with one or two upper extremities and both lower extremities involved.

The extent of paralysis has an important influence on the end result as is shown subsequently.

Lateral Curvature

In thirty-eight patients the spine showed a lateral curvature of varying degree.

Difference in Length of Legs

The average difference in length between the sound or less affected leg and the paralyzed leg was one and one-half inches.

Prior Treatment

All of these patients had worn braces, either stiff-knee or with a catch at the knee to allow flexion while sitting. Many of them had worn braces for both legs. They had all had massage and some of them various forms of electricity. Two or three of these patients had had a biceps tendon transplant into the patella which had failed to stabilize the knee joint.

Reason for Submitting to the Operation

Invariably the reason was to get rid of the brace and at times to get rid of one brace. Anyone who has seen these patients return time after time for brace repair, new braces, etc., and realizes that without the brace they are helpless, will readily understand their eagerness to discard the brace. These patients had reached sufficient age to enter into the decision themselves.

Age at Time of Operation

The average age was between fifteen and sixteen years. The two youngest patients were nine years and the oldest thirty-three years. The matter of age at time of operation had an extremely important bearing on the end result to be shown subsequently.

The Operation

This was without exception the procedure described by Hibbs in his paper previously referred to. The knee joint is exposed by a transversely curved incision below the patella, deepened to the joint. The cartilage is removed from the articular surfaces of the femur and tibia. The patella is denuded of its articular cartilage and is usually entirely freed from its attachment. A groove is made in the intercondyloid area of the tibia and femur into which the patella is mortised. The periosteum of the patella is sutured across the front of the former joint line. The incision is closed with catgut sutures throughout, using chromic catgut for the skin as the dressing is not disturbed for several weeks.

Immobilization was by plaster-of-Paris spica for the first few weeks and

FIG. 1

Shows a roentgenogram of a knee that was fused for instability due to anterior poliomyelitis. Note the bony trabeculation extending from femur to tibia.

long leg plaster-of-Paris circular splint subsequently. The plaster-of-Paris dressing was applied for an average of nine months after operation. In eight cases fusion was found to be solid and support was abandoned in four months or less. A few patients wore plaster over a year, one for eighteen months.

Weight-Bearing

The patients began to bear weight at an average time of two and one-half months after operation, many of them as early as five or six weeks.

Postoperative Complications

Immediate: Wound healing in all instances was uneventful and no postoperative infections were recorded. There was one case of severe acidosis.

Remote:

Fractures. Twelve patients, or thirteen and five-tenths per cent. of the entire group, had fourteen fractures of the leg with the fused knee. These occurred from two weeks after leaving the hospital to seventeen years after operation. Seven of these fractures were through the fused area, four were in the tibia, and three in the femur. This does not seem to be a very high incidence of fracture. One would expect a leg without a knee joint to be fractured more frequently than a normal leg. These patients, for the most part, engage in little exercise more strenuous than walking, however.

Flexion deformity. A varying degree of flexion deformity was found to have developed in all but nine of the ninety patients examined. This deformity almost invariably occurs at the epiphyseal line of the tibia or femur and not through the area of fusion.

Of the eighty-one patients showing flexion deformity in the fused knee, sixty-two, or seventy-seven and five-tenths per cent., had fifteen degrees or less. The average deformity was ten degrees. This can be disregarded and in fact is, in a measure, helpful to these patients.

The group of eighteen patients with severe flexion deformity from twenty-five to forty-five or fifty degrees is quite a different matter. They are with one exception found in the younger group of patients, under fifteen years of age at the time of their operation.

Three of these patients had knee stretching under anaesthesia after operation and one of them had two of these procedures.

Twelve of these patients, sixty-six per cent., required an osteotomy to correct their flexion deformity and two of these had the osteotomy repeated because the flexion deformity recurred.

Knock-knee. There were fifteen patients who developed knock-knee deformity after the operation. This deformity was almost always associated with flexion deformity. There were three operations for correction of postoperative knock-knee.

Failure of fusion. Two cases showed failure of fusion, two and

two-tenths per cent. One of these was revised at this hospital and another was done at another hospital.

Other Operations Performed

These patients presented a fertile field for the orthopaedic surgeon. Of the ninety patients, only five definitely required but the one operative procedure, a knee fusion. The remaining eighty-five patients had, beside the knee fusions, 204 additional operations to stabilize various joints or correct deformities. This makes the total number of operative procedures for the entire group, including the ninety knee fusions, 294 or three and two-tenths operations per patient.

Follow-Up Examination

The difficulty of estimating end results in these cases of knee fusion is great, because each is rather complicated. Almost invariably each patient had had several stabilizing operations, the success or failure of which was bound to influence the functional result of the knee fusion.

The length of time elapsing between the operation and the follow-up examination was long, an average of five years and eight months per patient. Five of them were seen eighteen years or more after operation. Within this long period the patients could almost certainly tell whether the procedure had been satisfactory from their standpoint. The chief objection to the fused knee is that it is awkward to handle in a street car, subway, theater, etc. The same may be said of a brace and the fused knee liberates the patient from the services of a brace-maker.

Patients' Attitude or Feeling toward the Operation

Of the ninety patients interviewed, only nine made no comment about their reactions to the operation or none was recorded by examiner.

The remaining eighty-one patients expressed themselves definitely and their reactions are worth listening to.

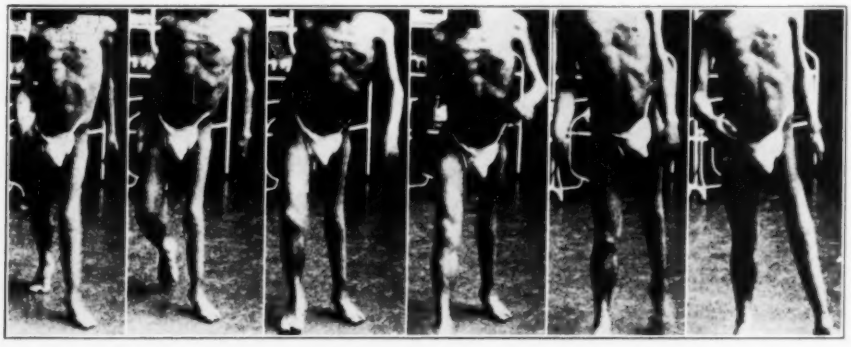

FIG. 2

J. S., Case 13614. A boy rather extensively paralyzed in left upper extremity, right upper extremity to lesser degree, left leg wide-spread paralysis. At the age of fourteen, in 1920, he decided to have his left knee fused to get rid of his brace. He had had his hip flexion released in both legs previously. He is pleased with his result and is able to work as a musician. The photographs show his gait in walking.

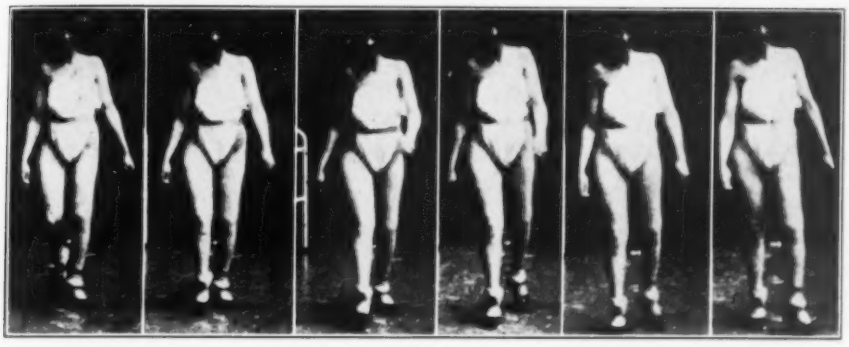

FIG. 3

M. J., Case 15358. A patient with her paralysis confined to one leg with a flail knee. After wearing a ring-lock brace for years, she decided at the age of fifteen years to have a knee fusion. Nine months after the operation she broke the leg which necessitated wearing plaster for seven weeks. She is now a housewife who does her own work without incapacity. The photographs show how well she manages her walking with the left knee fused. Patient is completely satisfied with the result.

Seventy-four of them, or ninety-one per cent., said they were satisfied, pleased, or delighted with the operation. They felt that they had been greatly benefited. Two were doubtful and five were disappointed.

Discarding of Braces

The great majority of the patients were enabled by the operation to discard a brace which was a primary object.

Sixty-seven, or seventy-four per cent. of them, use no braces at all, while the remaining twenty-three required some support such as crutches, cane, or brace.

Difference in Length of Legs

At postoperative examination, the average difference between the sound or least affected leg and the paralyzed leg was one and three-fourths inches, which is only one-fourth inch more than the average difference before operation. It can therefore be definitely stated that the operative procedure does not materially shorten the leg.

Economic Status

A brief survey of the group from this standpoint showed:

Forty-five patients of the seventy-six whose economic status was determined were working and financially independent.

Thirty-one patients were dependent, among whom were many minors and school children.

The occupation of these patients has varied with their mental capabilities and as a class they have not seemed to be unduly handicapped, unless they have had too much paternalism thrust upon them and sagged beneath it.

Operative Results

These were rated from a cosmetic and functional standpoint. A good or excellent cosmetic result is one in which the patient has a solidly

fused knee with but little flexion deformity or knock-knee; and a good or excellent functional result is one which allows the patient to discard his brace, walk reasonably well with distinctly improved function.

It is quite possible to have only a fair cosmetic result with very good function. The opposite is equally possible but not so frequently.

The end results were rated as follows:

	Poor	*Fair*	*Good*	*Excellent*
Cosmetic	2	10	24	54
Functional	3	7	22	58

It will thus be seen that seventy-eight of the ninety patients, or eighty-five per cent., had good or excellent cosmetic results and eighty, or eighty-eight per cent., had good or excellent functional results, which amply justifies this operative procedure.

There were only two frankly poor end results from the cosmetic, and three from the functional standpoint.

There were ten fair cosmetic, and seven fair functional results.

Factors Having a Definite Bearing on the End Result:

I. *Extent of paralysis*

(*a*). The cases showing paralysis of only one lower extremity were eighteen in number, of which twelve, or sixty-six per cent., were rated excellent; six, or thirty-three per cent., good; in other words, 100 per cent. were good or better.

(*b*). Cases with upper extremity paralysis and paralysis of only one lower extremity were five, all rated excellent, 100 per cent.

(*c*). Cases with both lower extremities involved to a considerable degree were forty-six in number, distributed as follows:

Excellent	20	43.5 per cent.
Good	19	41.5 per cent.
Fair	5	10.5 per cent.
Poor	2	4.5 per cent.

(*d*). Cases with both lower extremities involved, one but slightly, numbered eleven, distributed as follows:

Excellent	8	72.75 per cent.
Good	2	18.25 per cent.
Fair	1	9.00 per cent.

(*e*). Cases with one or two upper and both lower extremities involved numbered ten, distributed as follows:

Excellent	4	40 per cent.
Good	2	20 per cent.
Fair	2	20 per cent.
Poor	2	20 per cent.

These ratings are a composite of both functional and cosmetic end results. It will be seen that with extensive paralysis the poorer results appear. There were eighteen cases with two flail knees in which one knee was fused. This worked pretty well if the unfused knee was somehow stabilized.

II. *Age of the patient at time of operation.* Of the twenty-three patients who were thirteen years and under at the time of operation, nine had a poor or fair cosmetic or functional result, almost forty per cent., compared with about fifteen per cent. of these results for the entire group of ninety patients. This matter of age is directly related to the factor to be discussed next.

III. *Flexion deformity and knock-knee.* Of the nineteen cases developing severe flexion deformity, twenty-five degrees or more, or knock-knee, ninety per cent. were fifteen years and younger at the time of operation, most of them under thirteen years of age. Fifteen of these cases required a postoperative osteotomy, twelve for flexion deformity and three for knock-knee.

SUMMARY

An analysis of the end results of ninety operations for fusion of an unstable knee due to anterior poliomyelitis is presented. The operation has been without risk and has resulted in no appreciable shortening of the leg. All but a small number of the patients were pleased with the end result. They were able to discard their braces and walk better. Eighty-five per cent. of them had good or excellent cosmetic and functional results. In the younger patients, thirteen years and less at the time of operation, postoperative deformity—flexion and knock-knee—is apt to occur. This is apparently due to gravity and unopposed action of the hamstrings on ununited epiphyses. Failure of fusion occurred in but two cases and was easily corrected by operative revision. The best results are obtained in those patients with paralysis limited to one leg, but the patients with both extremities involved are greatly benefited.

BIBLIOGRAPHY

1. Beck, C.: The Surgical Treatment of Infantile Paralysis by Arthrodesis. Medicine, II, 365, 1896.
2. Boorstein, S. W.: End-Results in 100 Cases of Anterior Poliomyelitis Operated on at Fordham Hospital. Surg. Gynec. Obstet., XLI, 149, 1925.
3. Bossi, P.: Innesti Ossei Liberi e Peduncolati nella Fissazione del Ginocchio Ciondolante Paralitico. Arch. Ital. di Chir., XIII, 677, 1925.
4. Bradford, E. H.: Tendon and Muscle Transference and Arthrodesis in Infantile Paralysis. Tr. Am. Orthop. Assn., XIV, 223, 1901; Med. News, LXXIX, 775, 1901.
5. Dollinger, J.: Arthrodesen bei der Kinderlähmung. Zentralbl. f. Chir., XVIII, 689, 1891.
6. Frauenthal, H. W. and Manning, J. V. V.: A Manual of Infantile Paralysis, With Modern Methods of Treatment, Including Reports Based on the Treatment of Three Thousand Cases. Philadelphia, F. A. Davis Co., pp. 361–363, 1914.
7. Gray, H. T.: The Stabilization of the Flail Leg. British J. Surg., XV, 390, 1928.
8. Guildal, P.: Om Behandlingen af "Det Paralytiske Knae". Bibliotek f. Laeger, CXX, 631, 1928.
9. Gwynne, C. N.: The Surgical Treatment of a Case of Infantile Paralysis of the Leg. Rep. Soc. Study Dis. Child., II, 267, 1901–1902.
10. Hallopeau, P.: Paralysie Infantile Traitée par Arthrodèses Multiples; Marche sans Canne ni Appareil. Bull. Soc. de Pédiat. de Paris, XXI, 345, 1923.

11. Hass, J.: Arthrodese des Kniegelenkes mittels Verriegelung. Zentralbl. f. Chir., L, 673, 1923.
12. Hibbs, R. A.: An Operation for Stiffening the Knee-Joint; with Report of Cases. Ann. Surg., LIII, 404, 1911.
13. Hofmokl, J.: Arthrodese im Rechten Kniegelenke, wegen Infantiler Lähmung dieser Extremität; Heilung. Ber. d. k. k. Krankenanst. Rudolph-Stiftung in Wien (1891), 385, 1892.
14. Jones, R.: Arthrodesis and Tendon Transplantation.
British Med. J., I, 728, 1908.
Certain Operative Procedures in the Paralysis of Children.
British Med. J., II, 1520, 1911.
The Surgical Treatment of Infantile Paralysis. Lancet, I, 1515, 1914.
15. Kajon, C.: Neues zur Arthrodese des Kniegelenkes. Arthrocleisis Genus Osteoplastica. Zentralbl. f. Chir., LI, 656, 1924.
16. Kummer, E.: Arthrodèse du Genou dans un Cas de Paralysie Infantile de l'Extrémité Inférieure Gauche. Rev. d'Orthop., V, 241, 1894.
17. Lovett, R. W.: The Treatment of Infantile Paralysis. Ed. 2. Philadelphia, P. Blakiston's Son and Co., p. 118, 1917.
18. Miller, O. L.: Paralytic Knee Fusions. Southern Med. J., XX, 782, 1927.
19. Nathan, P. W.: The Mechanical and Operative Treatment of Poliomyelitis Anterior. Am. J. Orthop. Surg., XII, 430, 1914–15.
20. Orr, H. W.: Infantile Paralysis (A Problem in Reconstructive Surgery). *In* Abt's Pediatrics, V, 500, 1924.
21. Propper, H.: Zur Arthrodese bei Schlottergelenken nach Essentieller Kinderlähmung. Wiener Klin. Rundschau, XIV, 389, 1900.
22. Smith, S.: Anchylosis of the Knee Joint as a Remedy for the "Dangle Leg" Due to Infantile Paralysis Affecting the Entire Limb. Med. Rec., XXXV, 367, 1889.
23. Sorrel, E.: Paraplégie par Paralysie Infantile; Arthrodèses Multiples Permettant la Marche. Bull. et Mém. Soc. Nat. de. Chir., LII, 796, 1926.
24. Soutter, R.: Technique of Operations on the Bones, Joints, Muscles and Tendons. New York, Macmillan Co., pp. 66–69, 1917.
25. Stoffel: Krankheitsbild und Behandlung der Schweren Formen von Kinderlähmung. Verhandl. d. Deutsch. Orthop. Gesellsch., XXI Kongress, p. 241, 1927.
26. Thomson, J. E. M.: A Comparative Study of the Relative Value of Various Surgical Procedures in the Treatment of Infantile Paralysis of the Lower Extremity. J. Bone and Joint Surg., VI, 627, 1924.
27. Todd, A. H.: The Possibilities of Operation in Infantile Paralysis. Lancet, I, 864, 1927.
28. Vulpius, O.: Ueber den Wert der Arthrodese.
Münchener Med. Wchnschr., LV, 332, 1908.
The Treatment of Infantile Paralysis. New York, William Wood and Company, pp. 61–68, 1912.
Die Bewertung der Arthrodesenoperation. Ztschr. f. Orthop. Chir., XLIV, 85, 1923.
29. V. Winiwarter, A.: Die Kniegelenke eines 10 Jährigen Knaben. Zentralbl. f. Chir., XII, 109, 1885.
30. Zinsmeister, O.: Ueber die Operative Behandlung Paralytischer Gelenke (Arthrodese). Deutsche Ztschr. f. Chir., XXVI, 498, 1887.

OSTEOCHONDRITIS DISSECANS

A Clinical Study of Twenty-Four Cases *

BY DON KING, M.D., ANN ARBOR, MICHIGAN

The first reference in surgical literature to articular loose bodies is found in the "Complete Works" of Ambroise Paré[1]. He records that in the year 1558 he removed a loose body, or "stone", from the knee, and the patient made a satisfactory recovery. In 1738 Alexander Monro[2] advanced the theory that a free joint body might, by trauma, be derived from the cartilage covering the bone end. This explanation for the origin of articular loose bodies was accepted and the problem was considered solved. A century later, Kölliker[3] discovered living cartilage cells in the normal synovial villi. Rainey's observations[4] led to the theory that these cartilaginous cells might, under certain conditions, become free in the synovial fluid, proliferate, and form loose bodies. This plausible and fascinating theory caused the temporary abandonment of the idea of articular cartilage origin. Thirty years later, Franz König[5] recognized and described a knee-joint condition, in which it was quite obvious that a circumscribed portion of the femoral articular cartilage had loosened and fallen free into the joint. It appeared to him as though this bit of cartilage had been dissected from the condyle by a low-grade subchondral inflammatory process. He, therefore, gave it the name "osteochondritis dissecans".

During the past six years at the University Hospital we have observed in nineteen patients twenty-four such osteochondritic joints (twenty knees, four elbows). The average age of onset in our series was eighteen years, showing that it is a disease of young people. Males were affected approximately four times as frequently as females (males, fifteen; females, four) and the average duration of their subjective symptoms before appearing at the clinic was two and three-tenths years.

HISTORY

From the standpoint of the clinical history, the twenty osteochondritic knee joints fell into three fairly well defined groups. In one group were the very painful, swollen, tender joints, locked in fifteen to forty-five degrees of flexion (four cases). The appearance suggested traumatic injury. The trouble began very suddenly a few days previous, subsequent to a twist or other minor injury. There was usually no history of previous disability. X-ray examination revealed an osteochondritic focus on the medial femoral condyle, with two or three loose bodies in the joint (Fig. 1).

The second group included cases which were asymptomatic. It

* From the Department of Surgery, University of Michigan.

occasionally happened that a roentgenogram of the supposedly normal knee, taken for comparison, revealed a definite osteochondritic focus, without free bodies in the joints. The body or "mouse" was lying quietly in its bed on the medial femoral condyle (Fig. 2). These patients had "slumbering" osteochondritis dissecans (two cases).

The largest number of cases fell in the third group (fourteen). In this group there was a history of definite trauma in three cases. The story was of a chronically troublesome knee joint during two or three years. The complaint was a feeling of soreness, or definite pain on weight-bearing, associated with swelling. "Giving way" and stiffness were also common. These symptoms were sometimes continuous but more often intermittent, and were often associated with recurrent sudden "lockings" of the joint on arising from the sitting or squatting position. Five of this group had felt a loose body in the joint. The history of locking is similar to that which is described by patients with meniscus derangement.

The four elbow-joint cases occurred in three patients, all of whom complained of pain, stiffness, and weakness. One patient was found to have slumbering osteochondritis of the opposite elbow.

FIG. 1

Case 3. Dr. J. L. M., aged 26. Osteochondritis dissecans, medial femoral condyle with loose body in intercondyloid fossa.

FIG. 2

Case 15. L. D., aged 19. Slumbering osteochondritis dissecans, medial femoral condyle.

CLINICAL EXAMINATION

The clinical findings showed considerable variation. Slumbering osteochondritic joints and those in which the body was only partially detached not infrequently appeared normal (eight cases—thirty-three and a third per cent.). Some osteochondritic joints showed only a meager collection of fluid. Others were considerably swollen and painful to pressure, with a flexion deformity of fifteen to forty-five degrees. Such acute joints were not red, but there was detected a slight local increase in temperature. A free body was sometimes felt in the subquadriceps bursa or lateral pouches of the knee joint (three cases—twelve and five-tenths per cent.). Five of our patients had bilateral involvement; three of these were not aware of pathology in the opposite joint (two knees, one elbow).

DIAGNOSIS

In only one case did history and clinical examination alone lead to a suspicion of osteochondritis dissecans, all the rest being diagnosed by x-ray examination (Table I). It is very interesting to note that the three most

FIG. 3-A

Case 8. H. F., aged 35. Anteroposterior view of old osteochondritic knee joint with loose bodies and arthritis.

FIG. 3-B

Case 8. H. F., aged 35. Lateral view of the same joint.

FIG. 4

Case 14. E. F., aged 16. Osteochondritis dissecans of the capitulum, right elbow.

usual diagnoses in these cases were torn cartilage, tuberculosis, and loose body.

In the x-ray plate of the knee joint the process was almost always found on the postero-internal articular surface of the medial femoral condyle (nineteen of twenty cases). The entire focus appeared as a well localized, almond-shaped area of lessened density, within which was a small sclerotic mass (Fig. 1). Occasionally in the condyle at the edge of the focus there was a cystic area resembling a series of signet rings of different sizes, opening into the focus bed. The articular cartilage over the focus had a shredded appearance. Small portions (Fig. 1), or rarely the entire sclerotic mass, appeared free in the joint. Old cases coming under observation for the first time usually had several loose bodies in the joint associated with arthritis (Figs. 3-A and 3-B). Occasionally in these cases the original osteochondritic process was healed to such an extent that it could easily have been missed, all attention being concentrated on the arthritis and the loose bodies.

In our four elbow-joint cases the osteochondritic focus was found in the capitulum (Fig. 4) and certain accompanying epiphyseal changes were observed. These changes consisted in irregularity, broadening, and flattening of the radial head (Fig. 5-A). In addition to free bodies, old elbow-joint cases showed increased length of the coronoid process in front, and a thickening of the superior olecranon surface behind (Fig. 5-B).

TABLE I

? Osteochondritis dissecans	1
No diagnosis ventured	3
? Torn cartilage	3
Tuberculosis	5
Loose body	5
Gonorrhoeal arthritis, later on "functional joint"	1
Knee strain	1
? Old fracture	1
Normal joint	1
	21
Slumbering osteochondritis dissecans	3
Total	24

POSITION OF BODIES

An osteochondritic fragment discharged into a joint may become a nucleus for a rapidly growing chondro-osseous loose body. These were observed to have a great tendency to migrate to the "quiet areas" of the joint. In the knee they were especially common in the posterolateral pouch, the subquadriceps bursa, or the anterior compartment. Having once settled in these "quiet areas", they showed no great tendency to migrate. In fact, they not infrequently became rather firmly attached to the synovial membrane (Fig. 6-B). We have demonstrated them in the same situation over a long period of time. Should an attack of pain and swelling occur in a joint which contains these loose bodies, it does not necessarily mean that one of them has been caught between the joint surfaces, because x-rays taken before and after such attacks have demonstrated the bodies in exactly the same situation. Of course, such evidence is not entirely conclusive, purely chondrous bodies not being visualized in the roentgenogram. Furthermore, one of the chondro-osseous bodies may have been temporarily caught and then returned to its old resting place.

FIG. 5-A

Case 6. G. J. B., aged 21. Old osteochondritis dissecans of right elbow joint, showing loose bodies and changes in the radial head.

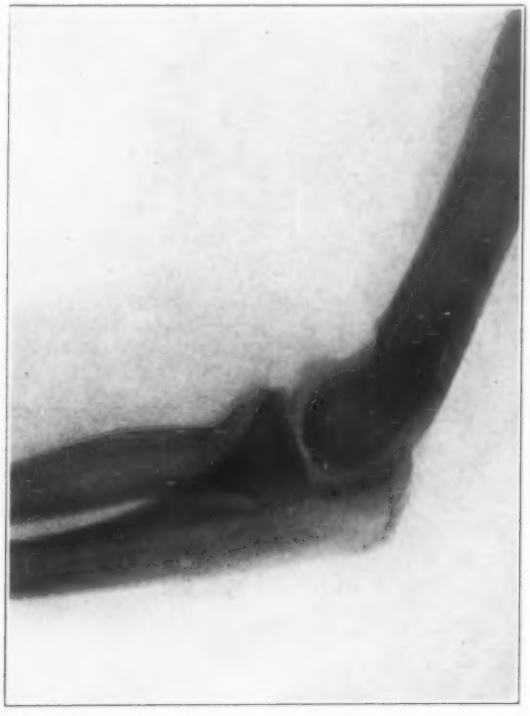

FIG. 5-B

Case 6. G. J. B., aged 21. Osteochondritis dissecans, left elbow.

FIG. 6-A

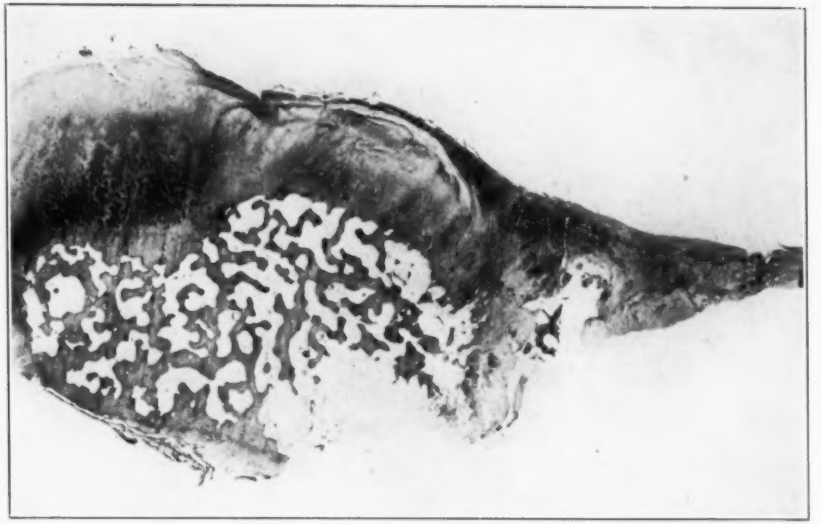

FIG. 6-B

Fig. 6-A. Case 20. C. S., aged 25. Low-power photomicrograph. Cross section through osteochondritic focus removed at operation.

Fig. 6-B. Case 20. C. S., aged 25. Low-power photomicrograph. Cross section through pedicled free body removed at operation.

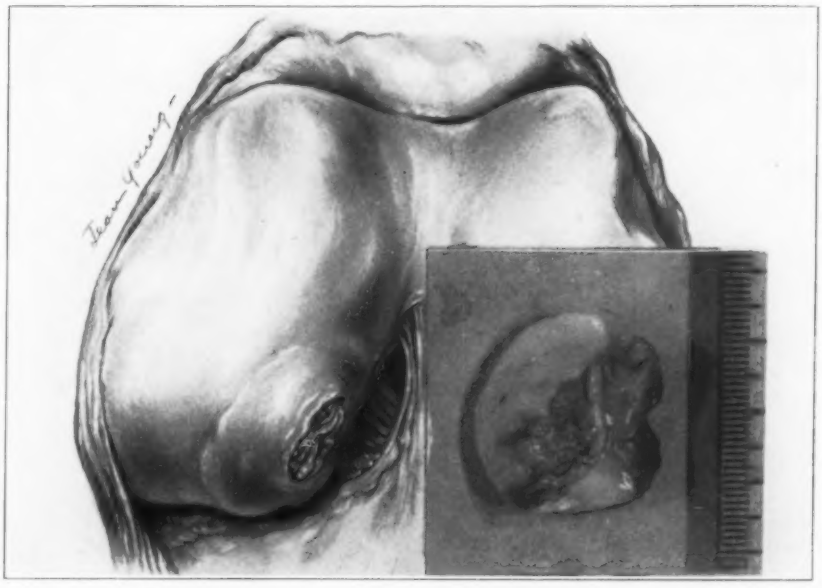

FIG. 7-A

Osteochondritic focus exposed at operation. Insert shows the same focus after removal.

FIG. 7-B

FIG. 7-C

Anteroposterior and lateral x-rays of removed osteochondritic focus. The cartilaginous covering almost completely surrounds the small bean-shaped bit of necrotic bone. A large piece of normal bone has been removed with the focus and forms the base of the specimen.

OPERATIVE RESULTS

Eighteen of our twenty-four osteochondritic joints were operated upon. On opening the joint the cartilage over the focus was found elevated above the general plane of the articular surface (Fig. 7-A). It was usually loose and its surface fissured. The body could easily be lifted out of its bed and carried with it a thin layer of osseous tissue. The bed thus exposed was not covered with connective tissue. For this study only nine cases (knee joint) were available, all others being eliminated because one year had not elapsed since operation (six cases), or because of failure to return to the clinic (three cases). Each of these nine joints had radical

removal of the focus, which implies extirpation of the body and thorough saucerization of the base, including a narrow rim of normal cartilage (Fig. 6-A). Six of the cases were between two and four years postoperative (Table II).

TABLE II

Time elapsing between operation and examination for this report:	
Six years	2 cases
Two to four years	6 cases
One to two years	1 case

A patient who offered no complaint and whose joint was found to be normal, except perhaps for a little swelling, and whose check-up x-ray showed no new bodies or arthritis, was considered to have an excellent result (six cases—sixty-six and two-thirds per cent.). Two patients complained of mild weakness and stiffness especially in the mornings. On examination they were found to have chronic synovitis with pain on extreme flexion and extension. Check-up x-rays were negative except for the residual operative defect. Both of these patients before operation had had recurrent lockings associated with severe pain and weakness over periods of two and three years. Their results, therefore, were considered good (twenty-two per cent.). One patient complained of a moderate amount of pain and weakness with some stiffness and swelling. Examination showed synovitis, mild crepitus, and pain on the extremes of motion with slight limitation. He was able to carry on his work as a farmer. Before operation he had been unable to do heavy work and had several loose bodies and arthritis. He was considered to have a fair result, his residual symptoms being due to the accompanying arthritis.

It is interesting that in contrast to our study, German reports show a higher percentage of elbow-joint than of knee-joint involvement, and conclude that the least extensive operation gives the most favorable end result[6, 7, 8].

PATHOLOGY

Figure 6-A is a cross section through an osteochondritic focus (knee). The fissure in the middle of the field separates the focus (left) from a thin layer of normal cartilage and bone (right). The cartilaginous cap shows areas of partial and complete degeneration, the underlying osseous portion being less viable than normal and its base partly surrounded by newly formed fibrocartilage. A chronic low-grade productive inflammation is present, especially in the marrow spaces which are partially filled with myxomatous connective tissue. Many foreign-body giant cells are present. The picture is one of necrosis with low-grade productive, aseptic, inflammatory response.

Figure 6-B is a section through a pedicled free body. At operation the pedicle was attached to the synovial membrane overlying the crucial ligament, while the body itself was lying free in the intercondyloid fossa.

Note the long connective-tissue pedicle and its partial extension over the superior margin of the cartilaginous cortex. The hyaline cartilage is thick and healthy. On the left, at the chondro-osseous border, the cartilage continues as fibrocartilage which almost completely covers the under surface of the osseous nucleus. A mild inflammatory reaction with foreign-body giant-cell formation is present and the bony nucleus is partly necrotic.

ETIOLOGY

The cause of osteochondritis dissecans is unknown. The various theories expressed in the literature have been well summarized by Wagoner and Cohn[9] and our clinical study has not thrown new light on this subject.

SUMMARY

1. Osteochondritis dissecans occurs primarily in males in the second decade of life, and is characterized by death of a special portion of the epiphyseal nucleus and articular cartilage of the knee and elbow joints. Other joints may be affected[10,11,12]. The condition was bilateral in twenty per cent. of our cases. There is a great tendency to loose-body formation.

2. A clinical history of recurrent locking in a young man, without a history of trauma severe enough to cause a fractured cartilage, suggests osteochondritis dissecans. The diagnosis is rarely made on history and clinical examination alone; x-ray is diagnostic. The presence of loose bodies in a knee or elbow joint, whose source is not obvious, suggests a previous osteochondritis dissecans.

3. Our study of a small series of operated cases shows that radical operation gives a good result in eighty-eight per cent. of cases. Slumbering osteochondritis dissecans should be treated conservatively without operation, as spontaneous healing has been demonstrated in these cases. Long-standing cases with many free bodies and severe arthritis may not be cured by operation, because many of the subjective symptoms are due to the accompanying arthritis.

BIBLIOGRAPHY

1. Paré, A.: Oeuvres Complètes. Paris, J. B. Ballière, III, 32, 1840–41.
2. Monro, A.: Part of the Cartilage of the Joint of the Knee Separated and Ossified. Medical Essays and Observations, IV, 305, 1738.
3. Kölliker, A.: Human Histology. New Syd. Soc. London, I, 329, 1853–54.
4. Rainey: (Discussion.) Trans. Path. Soc., II, 110, 1848–50.
5. König, F.: Lehrbuch der Allgemeinen Chirurgie für Aerzte und Studirende. Berlin, A. Hirschwald, p. 751, 1889.
6. Löhr, W.: Epiphysenstörungen im Ellenbogengelenk, zogleich ein Versuch der Genetischen Erklärung der Osteochondritis Dissecans. Arch. f. Klin. Chir., CLXII, 489, 1930.
7. Von Staa, H.: Zur Frage der Operation bei der Osteochondritis Dissecans. Arch. f. Klin. Chir., CLXI, 281, 1930.

8. Löhr, W.: Dauererfolge bei der Behandlung der Osteochondritis Dissecans (König). Arch. f. Klin. Chir., CLVII, 752, 1929.
9. Wagoner, G., and Cohn, B. N. E.: Osteochondritis Dissecans. A Résumé of the Theories of Etiology and the Consideration of Heredity as an Etiologic Factor. Arch. Surg., XXIII, 1, 1931.
10. Bergmann, E.: Osteochondritis Dissecans des Hüftgelenks. Deutsche Ztschr. f. Chir., CCXVIII, 400, 1929.
11. Lange, M.: Zwei Fälle von Doppelseitiger Osteochondritis Dissecans (König) der Femurköpfe. Ztschr. f. Orthop. Chir., LI, 269, 1929.
12. Läwen, A.: Über Osteochondritis Dissecans am Talocruralgelenk und Ihre Operative Behandlung. Zentralbl. f. Chir., LVI, 2498, 1929.

KYPHOSIS ADOLESCENTIUM *

BY PROF. BEDŘICH FREJKA, BRNO, CZECHOSLOVAKIA

Kyphosis adolescentium was first described by Scheuermann, Copenhagen, in 1921, and in Germany it is frequently termed "*Scheuermann's Kyphose*". Mau, Sorrel and Delahaye, Grobelski, and Buchman attribute the disease to the changes in the spinal epiphyses and consider this condition to be definitely similar to the Calvé-Legg-Perthes' disease. This opinion, however, does not tally with the fact that this affection is not limited to the period from twelve to twenty-five years of age, for it is frequently observed in the first decade of life, before the epiphyses are developed.

It is not until the twelfth year, and it is usually during the fourteenth and fifteenth years, that the small toothed projections of the so called epiphyses appear in the cartilage, gradually increasing in size. At the age of sixteen, these are fully developed, both in the thoracic and lumbar vertebrae, and remain separated from the vertebral body until the twentieth to the twenty-fifth year. They are designated by Scheuermann and Mau as the special epiphyses and suggest in detail an analogy to the epiphyses of the mammalia. Although other authors regard this bone kernel as a typical epiphysis, Schmorl considers it has nothing in common with the other epiphyses of the body. The physiological function of these so called epiphyses is, according to Schmorl, to join firmly the vertebral body to the intervertebral plate, and this union is so firm that occasionally by trauma to the epiphysis a triangular section is torn from the vertebral body. On the other hand, Mau maintains his original opinion and states that the Schmorl plate is the real epiphysis, and bases his argument on its obvious phylogenetic relation to the epiphyses of mammalia.

In the development of kyphosis adolescentium, Mau distinguishes three stages: (1) the onset, which soon passes into, (2) the stage of deformity, which exists usually for a long time (two years or more) with gradual increase of the condition, and, finally, (3) the stage of reparation.

Mau considers it quite typical that this stage depends upon the period of growth, and the x-ray shows that the irregular, toothed, indistinct outline of the vertebral bodies again becomes clear, the atrophy disappears, the anterior edges of the vertebral bodies develop areas with spurs, which change in severe cases, with the result that the anterior part of the body becomes saddle-shaped. In some instances, osseous bridges develop between the bodies, which are frequently noted in the later periods, when the deforming inflammatory changes in the vertebrae begin. Mau explains the origin of this condition as due to overloading of the spine at the time when the epiphyses are developing and the blood vessels nourishing the epiphyses become injured and finally obliterated, which

* From the Surgical Clinic of Prof. J. Petřivalský.

results in a necrosis of the epiphyses. Mau has succeeded in producing this experimentally in rats. Observations also have been made on this subject by Sorrel, Delahaye, Buchman, Grobelski, Janker, and Lyon.

Calvé and Galland have described a kyphosis accompanying the retropulsion of the nucleus pulposus, and have reported two types of cases: those without paraplegia, and those with paraplegia, the cause of which seemed to be a disturbance of the development of the primitive cord.

Schmorl explains the origin of kyphosis adolescentium by cartilaginous "knots" and originally thought that these cartilaginous knots occurred only in the adult age, and that, when the endochondreal growth was completed, disturbances could appear, with the result that the plates would be less resistant to the expansive power of the nucleus pulposus. After further observation, he places the origin at a much earlier period, and believes that the actual cause of the kyphosis adolescentium is undoubtedly a disturbance in the development of the intervertebral discs. Among 4000 spines, he did not find a single instance of the disturbance of the epiphysis. He observed a slight bursting out of the intervertebral plate in its pure form only in small children, but he seldom found it in the second period of development. Such asymmetries cannot be regarded as pathological phenomena, but only deviations of development within the normal physiological limits, and they assume a pathological character only from the effect of overloading. These changes show themselves as round or toothed projections of the intervertebral plate into the bone tissue in the places where the slipping is most pronounced. With the overloading, the tissue of the nucleus presses into the openings of the body, causing an atrophy of the bone beams in this vicinity, which often penetrates into the spongiosa. Further progress in the bone is stopped by reactive changes in this vicinity which result in a sclerotic condensation and a walling off of the knot. These small furrows in bone Schmorl considers as characteristic of kyphosis adolescentium. They differ from the changes in osteoporosis, in which they are usually limited to the region of the nucleus pulposus, and as a rule appear only in one vertebra. Schmorl explains the origin of the kyphosis by the disproportion that exists between the resistance of the intervertebral plate and the weight, and, according to him, this condition can originate only in the period of adolescence. He is convinced that his theory explains the fact that kyphosis can develop quickly as the result of the sudden overloading of the spine; it develops especially in farm laborers who work in bent positions and also it can develop gradually as the result of moderate trauma. All of this coincides with the clinical experience, that physical exercise exaggerates the condition and is contra-indicated.

In spite of the authority of Schmorl, the author does not think that this thoroughly explains all the phenomena which accompany kyphosis adolescentium. It fails to explain the blurred outlines of the anterior part of the vertebrae in the early stages of the affection, and does not explain the typical cycle lasting two or three years, so well described by Mau. It is evident that this same change must be explained, when it occurs in the

course of a definite disease, such as acute and chronic inflammation, and particularly in tuberculosis, and it is not surprising that Calvé in 1922, and Buchman in 1925, considered this condition to be a mild infection of the epiphysis.

In the Clinic of Prof. Petřivalský of Brno, the author has had the opportunity of studying three cases, which indicate the direction of further research.

Case 1. A boy, sixteen years old, pupil in secondary school, healthy, strong, and well developed.

Family history: Tuberculosis in a cousin of the mother at twenty-five years. One brother of the father died of tuberculosis at age of twenty; another died in ninth year with "typhus," which was said to be accompanied by persistent fistulæ on the face. Sister of father died of inflammation of cerebral membranes. Only one brother of the father was living and well. From the age of forty the father had had a form of catarrh, was pale, anaemic, thin; from 1916 to 1920 he had had a purulent and persistent inflammation from the middle ear.

The patient himself had had some form of catarrh from the age of four, when he had scarlet fever and diphtheria, followed by persistent cough, and complicated by double inflammation of the ear, with discharge. Since this period there have been frequent attacks of angina and catarrh. At the age of eight he had a tonsillectomy which resulted in improvement for only about a year and a half; between eight and ten, he had a return of the catarrh and of the middle ear, followed by defective hearing, and blepharitis. Later he developed pleurisy and was treated by heliotherapy at the sea. At the age of fourteen, he had another attack of pleurisy and at this time developed a strongly positive

Fig. 1

Case 1. Lateral roentgenogram.

Fig. 2

Case 1. Anteroposterior roentgenogram.

von Pirquet reaction. No involvement of the spine was detected, but, from the age of eight, there was a disinclination to exert himself, to take long journeys, or to play, and a very marked tendency to rest recumbent. There was always a disinclination for any exercise involving spinal strain. This was in sharp contrast to an active mental development.

The clinical condition then improved. In 1928 the patient became more resistant to infections, began to swim, and the reluctance to exertion disappeared, but there remained a definite rounded kyphos of the spine. The condition at present shows a marked dorsal kyphosis, rigidity of the entire thoracic region, but no sensitiveness. X-ray, lateral view, shows a typical picture of Scheuermann's kyphosis. The vertebral bodies are wedge-shaped, particularly in the anterior portion, with irregular toothed outlines. The trabeculae in the anterior part of the bodies apparently have been rebuilt; the outlines are unevenly toothed, but they are distinct, and in some areas show a distinct sclerotic condensation. The anteroposterior view, focused on the eighth dorsal vertebra, shows the area from the seventh to the ninth thoracic vertebrae screened by the dense shadow; the intervertebral plates are scarcely visible; along both sides of the spine there is a dense shadow of an abscess, which ends sharply in a pear-like shape, on the right of the eleventh dorsal vertebra. The spine shows a lateral deviation in an S curve, with the deviation to the right of the upper portion, and with the apex at about the eleventh thoracic vertebra.

On examination of this patient one and one-half years ago, the first indication for treatment was to consider the patient as having a spondylitic abscess, but the sedimentation test and von Pirquet reaction were both normal. Prof. Teyschl, who formerly treated this patient during the acute stage of the illness, stated that at that time, the tuberculous reactions were distinctly positive. The following treatment therefore was decided upon: the avoidance of gymnastics, with the exception of breathing exercises and swimming; restricted activity, particularly that incurring physical exhaustion; no apparatus or recumbency was ordered. Today, after one and one-half years, the condition of the patient is good, the spine is rigid as formerly, otherwise the patient is healthy, strong, and sunburned and has no symptoms. The defect of the spine has not increased.

Case 2. Girl, thirteen years old, pupil in secondary school.

Family history: Father gave history of pulmonary tuberculosis, with hemoptysis, for a number of years. Mother had had gastro-intestinal disturbance.

The patient at early age was apparently strong and well. At the age of three the child had whooping cough, after which the parents observed that the posture was not normal; there was no pain. The patient carried on gymnastic exercise for one year, which improved the condition, after which she was discharged as cured. At the age of six she had chickenpox; at seven, scarlet fever; at eight, measles; at nine, influenza and scarlet fever, followed by nephritis; at ten the parents noticed that the child's posture was incorrect and that she did not walk straight, but the defect was comparatively slight, and no attention was given to it. At the age of twelve a gymnastic teacher called attention to the fact that the defect was increasing, and the patient was sent to be examined.

Examination showed the patient healthy and well developed, strong and tall. The von Pirquet reaction was negative. The dorsal spine showed a kyphos, with the summit of the curve between the eighth and ninth dorsal vertebrae, with rigidity between the second and eleventh vertebrae, but no sensitiveness.

Roentgenogram, lateral view, shows a moderate posterior curve, the thoracic vertebrae slightly wedge-shaped, the most marked changes in the eighth and ninth dorsal vertebrae. In the vertical plane the body of the eighth vertebra is twenty millimeters in the anterior, and twenty-six millimeters in the posterior portion; the anterior portion is slightly saddle-shaped. In the anterior portion of the intervertebral disc is a small bone shadow corresponding to the appearance of a developing epiphysis. The body of the ninth vertebra is twenty millimeters in height in the anterior, and twenty-nine

FIG. 3

Case 2. Lateral roentgenogram.

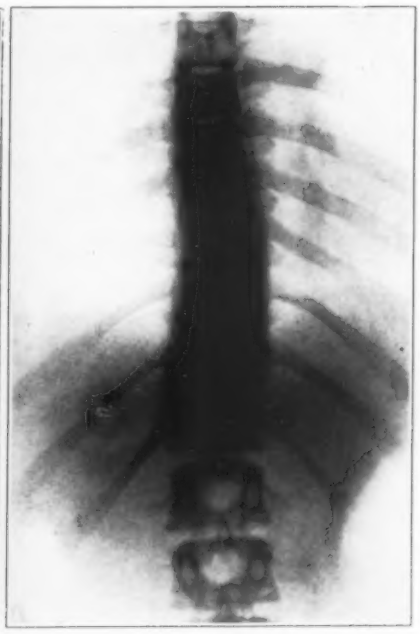

FIG. 4

Case 2. Anteroposterior roentgenogram.

millimeters in the posterior portion; concave and saddle-like in the anterior portion, and shows in this area, six millimeters from the margin, a tooth-like projection three millimeters in depth; the margin of the vertebra shows condensation. The tenth and eleventh vertebrae anteriorly are normal, broad, slightly saddle-shaped, and the anterior portion of the body slightly pointed. The outlines of the bodies are clear and distinct. In the anteroposterior view, the spine shows a slight S curve on the left opposite the ninth and tenth vertebrae, and the upper portion of the curve is from the sixth to the seventh dorsal vertebrae. The plates between the seventh and eighth, and eighth and ninth, and also between the ninth and tenth are less distinct than between the other three vertebrae, and the spine in this area shows a lack of clear outlines. At the right side of the spine, from the ninth to the tenth vertebrae there is a slight shadow, three to four millimeters broad, ending sharply at the height of the diaphragm. In the upper portion, this shadow disappears gradually at the level of the ninth dorsal vertebra. This cannot be designated for a certainty as a spondylitic abscess, but corresponds to the appearance of an abscess which probably existed sometime previously. It is possible that the slight indistinctness of the eighth and eleventh vertebrae has been caused by the fibrous tissue which has developed in the area of the original tuberculous process. The x-ray is not a typical illustration of Scheuermann's kyphosis, although clinically the affection cannot be distinguished from the kyphosis adolescentium, and the process is quite typical. The patient was treated by orthopaedic gymnastics, with an improvement of posture in a comparatively short period. Nine months later the patient still practises gymnastic work daily, is in good condition, and the defect is not particularly noticeable, but the spinal column remains rigid.

CASE 3. Woman, twenty-eight years old. Family history good. The woman was well until February 1922; was then obliged to have some special treatment after an attack of influenza; in June came for consultation in regard to constant pain in upper dorsal

vertebrae. The spine, as shown by anteroposterior view, appeared normal; the patient remained under treatment until the end of July 1923; there was strong positive tuberculous reaction. The case was treated as one of tuberculosis, but repeated x-rays of the dorsal spine were negative. The patient was employed as a secretary, using a typewriter, and after a particularly busy period, symptoms increased and she was unable to hold herself erect, but after a week of rest, the pain disappeared. At the end of October 1923 her condition was so good that she was given permission to marry. No ill effects followed the birth of a child in 1925, and symptoms did not reappear until January 1926, when the general condition was very much depleted by nine months of nursing, and at this time she began to have pain in the back, which disappeared after a rest. Following this there was occasional reappearance of pain, particularly after overwork, but with improvement after rest. X-rays at this period showed no change in the spine. The condition remained practically the same, with occasional relapses of pain and sensitiveness, but with recovery; increased at one time when living in a damp area. In 1929 the patient had an attack of influenza, after which pain returned and persisted.

Examination at present shows the patient in apparently good condition, with increased weight. She has a child of five years, who shows considerable swelling of glands, but otherwise is apparently healthy.

The woman complained of muscular pain in back, and showed on examination a rigid spine, with moderate degree of rounded kyphosis; there was no sensitiveness of spine; von Pirquet reaction was strongly positive, both in the mother and the child.

Roentgenograms in lateral view show moderate backward curve; the vertebral bodies are somewhat wedge-shaped, and the anterior surface saddle-shaped with margins projecting, with rather prominent sclerotic condensed edges; the vertebral bodies and the intervertebral discs are well preserved, except that the body of the seventh and adjacent parts of the sixth and eighth vertebrae show a reforming of the trabeculae, and

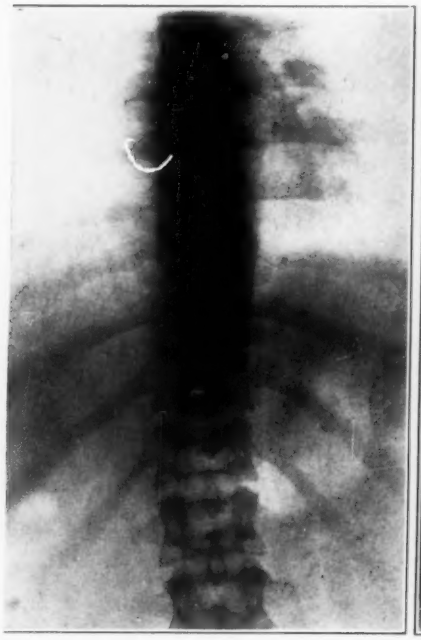

FIG. 5

Case 3. Anteroposterior roentgenogram.

FIG. 6

Case 3. Lateral roentgenogram.

the intervertebral discs in this area are hardly visible. The margins of the seventh vertebra are the most prominent. The anteroposterior view shows from the seventh to eleventh dorsal vertebrae a loss of contour of the vertebral bodies and the intervertebral discs hardly visible, blurred by a shadow; a lateral S curve, with deviation toward the left, at level of the eighth dorsal, and with the compensatory curve toward the right of the level of the twelfth dorsal vertebra. On the right of the dorsal spine, between the seventh and tenth vertebrae, is a faint oblong shadow, from five-tenths to one centimeter in width, which at the level of the tenth vertebra fuses with the shadow of the spine and merges with it. The lungs show an old cured process of tuberculosis.

The roentgenograms do not show the typical findings of Scheuermann's kyphosis, but are cited only as evidence that a long-lasting and rather undetermined affection of the spine can result from an infection of tuberculous origin, the existence of which cannot be doubted. At present the tuberculous process in this patient is still active, and she is still under local and general hygienic treatment; she is having slight pain in the back only in the morning, and but few symptoms during the day; she is not able to do heavy work.

DISCUSSION

In the foregoing cases there is undoubtedly tuberculous involvement of the spinal column. These cases show the condition in patients of different ages: the first, in whom the illness began at the eighth to the tenth years and, who, at the age of sixteen shows complete cure; the second case, a girl in whom the condition developed between the fourth and sixth years and who at the age of thirteen is cured; and the third case, a woman of twenty-eight, in whom the condition developed seven years ago and is now in the stage of reparation, not quite complete. The onset of the condition in these cases has no relation to the development of the vertebral epiphyses.

The x-ray findings in the first case are identical with pictures of Scheuermann's and show added shadows of an oblong abscess, which completes the picture of the tuberculous process. In the second and third cases, the findings are rather unusual for a round back, and in the third there is evidence of the vertebra being affected by tuberculosis.

In the comparison of these round backs with the findings in bone and joint tuberculosis, it is seen that these cases, as well as those reported by others, support the theory of the gradual development of bone and joint tuberculosis. According to Mau, in the newly rounded backs, the outlines are indistinct and blurred; after about two years the outlines of the vertebrae become more distinct, but are uneven and toothed; and finally in the cured cases, the toothed outlines show a condensed and sclerotic appearance with a partial elimination of the uneven surfaces.

The question is as to what form of tuberculosis may result in these changes.

It is evidently not the usual form which is seen, described as Pott's disease, for during the usual course of this affection, there is a beginning destruction and disappearance of the intervertebral discs. On the other hand, in the cases of kyphosis described above, the intervertebral plates remain preserved, and merely become somewhat narrower, particularly in their anterior portions. The x-ray shows the presence of the tubercu-

lous abscess, situated in the anterior portion of the vertebral bodies under the anterior ligament, an abscess which, in contrast to the usual forms of tuberculosis, does not penetrate as far as the vertebral bodies and the intervertebral discs, but remains on the surface and shows itself externally.

In the writings of Schmorl, or during the author's inspection of Schmorl's large collection, he was unable to find any condition which would correspond to this picture.

In Ménard's work in 1900, there are given illustrations of spinal columns in which a tuberculous abscess spreads from the site of the affected vertebra a considerable distance in both directions, along the anterior portion of the spine, eroding only the surface of the vertebra, not penetrating into its structure, and not disturbing the intervertebral discs.

The course of the affection in our cases is typical, and suggests a relation to this form of tuberculous disease. In the early period, the patient suffers sometimes from slight back pain, and again the disease manifests itself only as marked malaise, and an unconscious avoidance of physical effort, and by exhaustion after even moderate exercise. The examination of the spine at this period by x-ray shows practically nothing, which is to be expected because of the fact that the involvement is more of the soft parts, and has not yet affected the bone.

Clinically, the period of slight pain lasts about two years, during which time there is gradual development, as seen by the x-ray, of the conditions described by Scheuermann and Mau as the first stage of the stiff round back. The outlines of the vertebrae become indistinct, as is found in the earlier tuberculous processes, more pronounced in the anterior portion, and gradually penetrating into the body in different degrees. Only later, according to Mau, is found the period of deformity, and later the stage of recovery, which stage is, in cases of tuberculosis, the period of repair, and finally of healing. The tuberculous process on the anterior portion of the spine becomes quiescent, is absorbed, leaving only a cicatricial area, and there is no reason to expect a return of the mobility of the spine.

As regards the origin of the tuberculous process in the anterior portion of the spine it is not possible to give an explanation. In the third case, with an active tuberculosis of the lungs, it may possibly have been an extension of the process by contiguity.

It is also difficult to explain or to give a definite opinion in regard to the final condition of the spine in these cases, and sometimes there is a resemblance to the kyphos of Bechtĕrev's disease, in which Marie and Leri found in anatomical specimens the anterior ligament ossified from the sixth to the twelfth vertebrae, and an ankylosis by a narrow area of bone along the anterior portion of the spine. There is also ossification of the ligaments between the spinous processes on the apex of the curve, and, in addition, areas of bone proliferation between the vertebrae, but which do not unite. Leri considers that this form of kyphosis appears after injury, in which the blow results in a straining of the anterior ligaments, following

which the ossification begins in the ruptured portions of the ligament. The final result is analogous to the condition in the paravertebral abscess, which also results in complete rigidity of the spine, with the rounded kyphos.

Meyer and Janker have found illustrations of the kyphos with the sclerotic outline of wedge-shaped vertebral bodies, but with no ankylosis in the anterior portion. It is possible that the milder cases of this affection show this final result.

As a whole, the cases described are interesting from a twofold point of view, showing first, that one of the causes of the "round, stiff back" may be tuberculosis; and second, that an inflammatory process of tuberculosis of the spine may pursue a mild course for a long time, without definite clinical or x-ray evidence, and the actual condition may not be demonstrable until after a period of several years.

It is obvious that all cases of round stiff back cannot be explained as due to a latent tuberculosis, for this is only one of the causes. Especially has it been demonstrated in recent years by Italian authors that the disturbances of the hypophysis can also produce the clinical picture typical of ykphosis adolescentium.

BIBLIOGRAPHY

Alcorn, J. M. and O'Reilly, M.: Osteochondritis of Vertebral Bodies. Med. J. Australia, II. 230, 1929. Abstracted in Fortschr. a. d. Geb. d. Röntgenstrahlen, XLI, 119, 1930.

Barsony, T. und Koppenstein, E.: Calcinosis Intervertebralis. Fortschr. a. d. Geb. d. Röntgenstrahlen, XLI, 211, 1930.

Brack, E.: Knorpelknötchen der Wirbelsäule und Unfall. Monatschr. f. Unfallh., XXXVI, 356, 1929.

Büchert: Die Erkrankungen der Wirbelsäule. Ztschr. f. Ärztl. Fortbild., XXVII, 11, 1930.

Buchman, J.: A Résumé of the Osteochondritides. Surg. Gynec. Obstet., XLIX, 447, 1929. Abstracted in Fortschr. a. d. Geb. d. Röntgenstrahlen, XLI, 315, 1930.

Calvé, J. et Galland, M.: Le Nucleus Pulposus Intervertébrale; Son Anatomie, Sa Physiologie, Sa Pathologie. Presse Méd., XXXVIII, 520, 1930.

The Intervertebral Nucleus Pulposus. Its Anatomy, Its Physiology, Its Pathology. J. Bone and Joint Surg., XII, 555, July 1930.

Campbell, W. C.: A Text-Book on Orthopedic Surgery. Philadelphia, W. B. Saunders Company, p. 174, 1930.

Hanson, R.: Some Roentgen Researches in Normal Spines of Children. Acta Chir. Scandinavica, LXIV, 219, 1928. Abstracted in Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXIX, 540, 1929.

Einige Röntgenstudien über "Normal" Rücken Während der Wachstumsjahre. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXIX, 1079, 1929.

Janker, R.: Die Epiphysen der Wirbelkörper und Ihre Veränderungen "Persistierende Wirbelkörperepiphysen". Fortschr. a. d. Geb. d. Röntgenstrahlen, XLI, 597, 1930.

Leri, A.: Études sur les Affections de la Colonne Vertébrale. Paris, Masson et Cie., 1926.

Études sur les Affections des Os et des Articulations (Colonne Vertébrale Exceptée). Paris, Masson et Cie., 1926.

Lyon, E.: Die Krankheiten der Zwischenwirbelscheiben. Arch. f. Orthop., XXVI, 295, 1928.

Lyon E.: Über Brüche von Epiphysen der Lendenwirbelkörper im Jünglingsalter. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVIII, 376, 1928.

Das Verhalten der Bandscheiben bei Typhöser Spondylitis. Fortschr. a. d. Geb. d. Röntgenstrahlen, XL, 635, 1929.

Menard, V.: Étude Pratique sur le Mal de Pott. Paris, Masson et Cie., 1900.

Meyer, H.: Röntgendiagnostik in der Chirurgie und Ihren Grenzgebieten. Berlin, Julius Springer, 1927.

Mikhailoff, M. und Tcherepnin, M. I.: Über die Wirbelknorpelinseln und Deren Röntgenbild. Fortschr. a. d. Geb. d. Röntgenstrahlen, XL, 1061, 1929.

Müller, W.: Das Röntgenologische Bild und die Klinische Bedeutung der Sogenannten Knorpelknötchen der Wirbelsäule. Bruns' Beitr. z. Klin. Chir., CXLV, 191, 1928–1929.

Schmorl, G.: Über Knorpelknötchen an den Wirbelbandscheiben. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVIII, 265, 1928.

Verkalkung der Bandscheiben der Wirbelsäule nebst Bemerkungen über das Verhalten der Bandscheiben bei Infektiöser Spondylitis. Fortschr. a. d. Geb. d. Röntgenstrahlen, XL, 18, 1929.

Über Knorpelknöten an der Hinterfläche der Wirbelbandscheiben. Fortschr. a. d. Geb. d. Röntgenstrahlen, XL, 629, 1929.

Die Pathogenese der Juvenilen Kyphose. Fortschr. a. d. Geb. d. Röntgenstrahlen, XLI, 359, 1930.

Stefko, W. H. und Schneider, J. J.: Pathologisch-Anatomische und Röntgenologische Untersuchungen über die Veränderungen der Wirbelsäule bei Chronischer Unterernährungen und Anderen Ungünstigen Äussern Einwirkungen. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVII, 247, 1928.

Uebermuth, H.: Die Bedeutung der Altersveränderungen der Menschlichen Bandscheiben für die Pathologie der Wirbelsäule. Arch. f. Klin. Chir., CLVI, 567, 1930.

Zatkin, S.: Zur Frage über die Scheuermannsche Krankheit. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXIX, 657, 1929.

EXCISION OF HEMIVERTEBRAE FOR CORRECTION OF CONGENITAL SCOLIOSIS

Report of Two Cases *

BY EDWARD L. COMPERE, M.D., CHICAGO, ILLINOIS

Congenital scoliosis is usually associated with a developmental abnormality in one or more of the vertebral bodies. The commonest change noted is that of asymmetrical development of the corresponding halves of the deformed vertebrae. This may vary from wedging to complete bifurcation of vertebral bodies into hemivertebrae with one half larger than the other, or complete absence of a corresponding half, or the interposition of one or more half vertebrae which are entirely accessory or supernumerary. These deformities cause a lateral deviation of the spine similar to that which would occur if a wedge were inserted between the lateral edges of a stack of a child's blocks. The additional factor of rotation which is seen in the older cases of scoliosis may not at first be present, since the dorsal convexity and lumbar concavity of the spine become obvious only after the upright position is assumed. Spina bifida is frequently present and may complicate any attempt to correct the deformity.

In 1926 Kleinberg[1] stated, "a curvature of the spine due to some congenital malformation of the vertebrae or ribs is incurable. The author has seen and treated a comparatively large number of congenital scolioses. He has used different methods in treating them, but has never seen any case permanently improved. Nor is this to be wondered at if one realizes that we have no means in the present state of our knowledge of either removing or correcting the cause,—namely, the malformation." This statement expresses the general consensus of opinion.

In a search through the literature it was found that Royle[2] had mentioned briefly the successful removal of part of a wedged vertebra in a child two and a half years of age, but no other report of a similar operation was found. Codivilla[3] in 1901 had suggested a similar operation, but the procedure was rejected as too dangerous.

In the cases here reported we were successful in removing hemivertebrae and in correcting the curvature of the spine.

Case 1. B. M., female, colored, was first seen when thirteen months of age. She was thought to be entirely normal until at the age of six to eight months, after she had begun to sit up, the mother noticed that the back curved (Fig. 1). The curvature slowly progressed and, when she began to walk at the age of twelve months, the deformity became quite noticeable. There was nothing to suggest the presence of spina bifida. An examination revealed a very well nourished, well developed, intelligent, and alert baby, with a rather acute left scoliosis curve at the dorsolumbar level. No other abnormalities or abnormal physical findings were noted.

* From the Department of Surgery, Division of Orthopaedic Surgery, The University of Chicago.

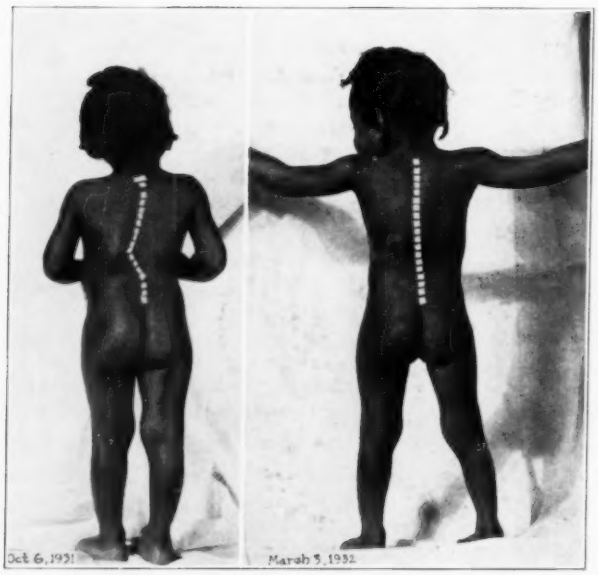

FIG. 1

Case 1. B. M. These photographs illustrate the appearance of the patient before operation and four and one-half months after excision of the hemivertebrae. The flare of the ribs on the left side of the chest, as well as the sharp curvature of the spine, has disappeared.

The father, aged thirty-six, and the mother, aged twenty-six years, were living and well. An older child was quite normal. No history of congenital deformities in any of the relatives of the child could be obtained.

Wassermann and Kahn tests were negative for the patient and for both parents. Neurological and blood cytology studies were entirely normal.

The x-ray examination (Fig. 2-A) revealed a congenital abnormality in the cervical region from the fifth cervical to the second thoracic vertebrae with spina bifida. Eleven dorsal vertebrae were present on the right side with fusion of the right tenth and eleventh ribs. Twelve ribs and twelve vertebrae were present on the left side. There were six vertebrae in the lumbar area on the left and five on the right side. The scoliosis at the junction of the thoracic and lumbar vertebrae with the curvature to the left was quite marked. The eleventh dorsal vertebra consisted of a left half only, while an accessory hemivertebra was wedged between the twelfth dorsal and first lumbar vertebrae on the left side, the two causing the sharply angled scoliosis.

OPERATION

The operation on October 12, 1931, was performed under ether anaesthesia.

A curved incision was made, extending from the eighth dorsal to the third lumbar vertebrae. The tips of the posterior spinous processes were identified and the prespinous fascia was incised. Using a blunt periosteal elevator, the left sides of the spinous processes and the corresponding laminae were bared. The erector spinae muscles were reflected laterally, and the transverse processes of the eleventh and twelfth dorsal and the first and second lumbar vertebrae were brought into view. These were quite small and were easily broken off with the periosteal elevator.

An incision parallel to the eleventh rib on the left side was now made, connecting with the longitudinal incision and extending laterally to the left for a distance of ten centimeters. Using a small rib stripper, the eleventh and twelfth ribs were denuded of all soft-tissue attachments. The twelfth rib was removed and a segment of the eleventh rib, six centimeters in length, was excised.

The column of spinal muscles was now retracted medially and the laminae and pedicles of the vertebrae from the eleventh dorsal to the second lumbar were exposed. Using the periosteal elevator, the parietal pleura was carefully dissected from the bodies of the lower dorsal vertebrae and the bodies of the eleventh and twelfth dorsal and first lumbar vertebrae were exposed laterally and anteriorly, so that the finger could pass

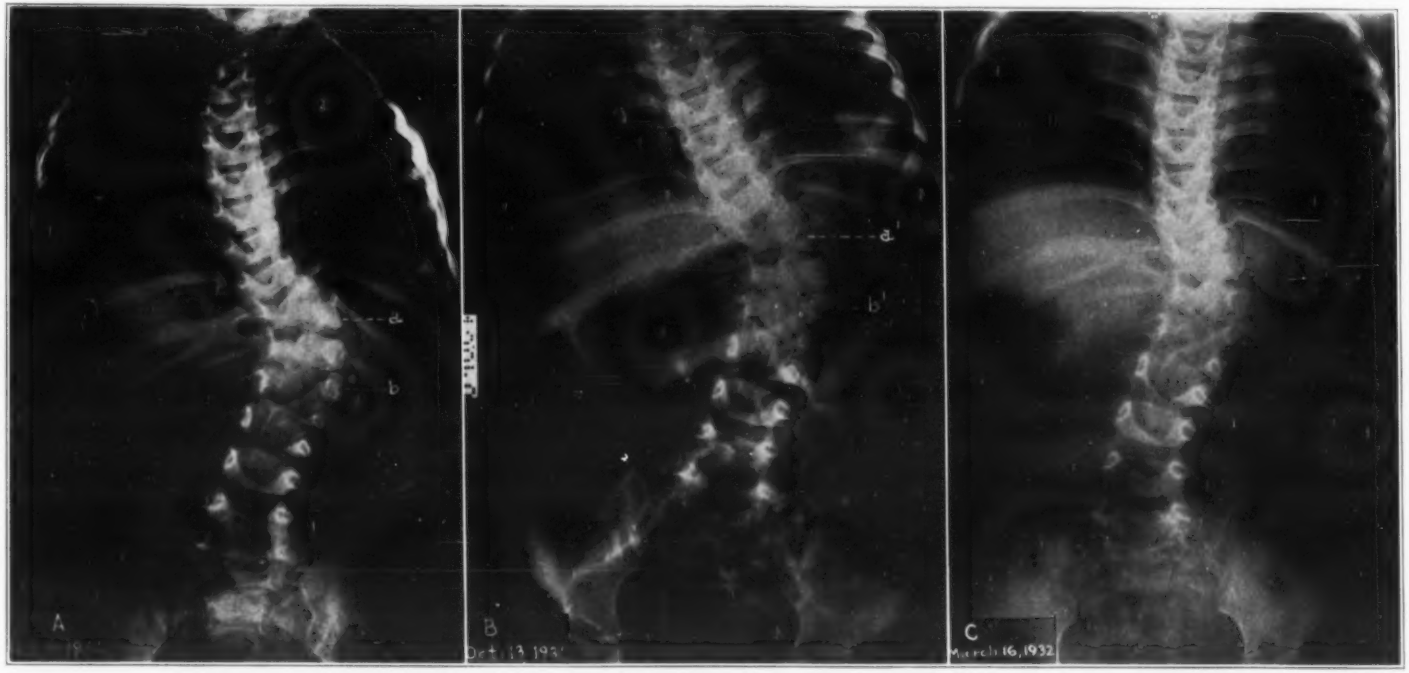

FIG. 2-A FIG. 2-B FIG. 2-C

Case 1. B. M. The multiple congenital anomalies are well demonstrated in the roentgenogram Fig. 2-A. Hemivertebrae *a* and *b* are acting as wedges to produce the marked lateral curvature.

Fig. 2-B. Illustrates the x-ray appearance of the spine after excising most of the hemivertebrae a^1 and b^1. Since the laminae were not removed and some fragments of the vertebral body remained attached to the cartilage-lined space, the full defect left in the vertebral column is not adequately demonstrated.

Fig. 2-C. The curvature of the spine has been improved.

completely around them. Care was exercised to avoid unnecessary trauma to the nerve roots, but the lateral lumbar veins were clamped and tied. A small tear in the pleura was plugged with a piece of muscle and the complete excursion of the lung could be readily demonstrated through the thin transparent pleura.

With a small chisel and a dissector the left eleventh dorsal hemivertebra was removed in several fragments of from three-tenths to one centimeter in diameter. It was possible, through the defect thus created, to palpate the dura. The left half of a vertebral body was removed from the level of the first lumbar vertebra, leaving a cartilage-lined defect. The corresponding laminae were only partially excised.

During this stage of the operation the patient was in mild shock and the radial pulse could not be palpated. The aortic pulsation, however, was easily obtained, was of good quality at all times, and varied in rate from 130 to 160 per minute. It was now possible, by exerting some pressure at the apex of the scoliosis curve, to obtain some degree of correction, but no attempt was made at this time to maintain the correction.

The muscles were sutured with plain catgut across the pleura and the defects created by the rib excisions.

The spinous processes and laminae on the left side were again exposed, roughened with a chisel, and curls of bone were turned laterally across the articular facets. The ribs which had been removed were split longitudinally and placed as grafts on the laminae, extending from the eighth dorsal to the third lumbar vertebrae.

Immediately after closure of the wound a transfusion of 350 cubic centimeters of citrated blood was given very slowly into the external jugular vein.

Convalescence was uneventful. The wounds were permitted to heal and sutures were removed before beginning forced correction. A plaster jacket was applied such as that described by Hibbs, Risser, and Ferguson [4] for scoliosis, including the left leg and body, and extending to the right side of the head. Hinges were incorporated in the cast anteriorly and posteriorly, with the axis placed directly over the twelfth dorsal vertebra. The cast was cut completely around at this level, an elliptical portion of cast was removed from the left side, and a turnbuckle was inserted on the right side of the cast. By gradually opening the turnbuckle, satisfactory correction was obtained over a period of three weeks, and this correction was maintained by removing the turnbuckles and filling in the cast with plaster.

X-rays of February 22 and March 16, 1932, showed definite correction (Fig. 2-C).

Microscopic sections of the fragments of the hemivertebrae show normal cancellous bone and normal marrow elements, to which is attached fibrocartilage. The patient is now ambulatory in a plaster jacket which includes the shoulders and pelvis.

Case 2. W. H., a white male, aged sixteen months, was admitted to the Hicks-McElwee Orthopaedic Hospital, December 8, 1931, for treatment of congenital deformities of the spine. He had been followed in the out-patient clinic since July 8, 1931.

Two weeks after birth of the patient, the attending physician told the parents that the spine was crooked. The curvature extended to the right, and the lumbar spine was curved posteriorly. The deformity gradually became more marked, and when the child began to try to sit up he slumped forward as though there were very little support from the lumbar vertebrae (Fig. 5-A). Roentgenograms which were taken two weeks after birth showed multiple abnormalities with bifid vertebrae and asymmetrical development of lateral halves (Fig. 3).

Examination following admission to this clinic revealed a right lateral scoliosis extending from the second dorsal to the third or fourth lumbar vertebra. The spinous processes of the second, third, and fourth lumbar vertebrae were quite prominent.

The blood Wassermann and Kahn tests of the father were positive (++++) and those of the mother were negative in repeated examinations, while the patient had a slightly positive reaction. Two subsequent tests of the blood of the patient were entirely negative.

X-ray examinations showed multiple congenital anomalies of the spine, with a wide,

rounded scoliosis curving to the right. There was failure of fusion of both the bodies and the laminae in the lower thoracic and in the lumbar regions of the spine. The scoliosis could be accounted for by the normal development of the right halves of the vertebral bodies, while the left halves of corresponding vertebrae were markedly underdeveloped, creating a curve with its convexity to the right. Rotation of the vertebral bodies was not marked. The greatest asymmetry in the development of the lateral halves of the vertebral bodies was noted in the first lumbar vertebra (Fig. 4-A). Although the patient was only sixteen months of age, excision of the large right half of this body and fusion of the bodies of the second and third lumbar and eleventh and twelfth dorsal vertebrae on the right side were advised.

OPERATION

The operation on December 14, 1931, was performed under ether anaesthesia. A curved incision was made just lateral to the tips of the spinous processes and extended from the level of the sacrum to the tenth thoracic spine. The right side of the spinous processes and laminae was bared by subperiosteal stripping. The right transverse processes of the first, second, and third lumbar vertebrae were fractured, and the right twelfth rib was excised. The bodies of these vertebrae were then exposed by carefully dissecting with a periosteal elevator from the base of the fractured transverse processes laterally and anteriorly.

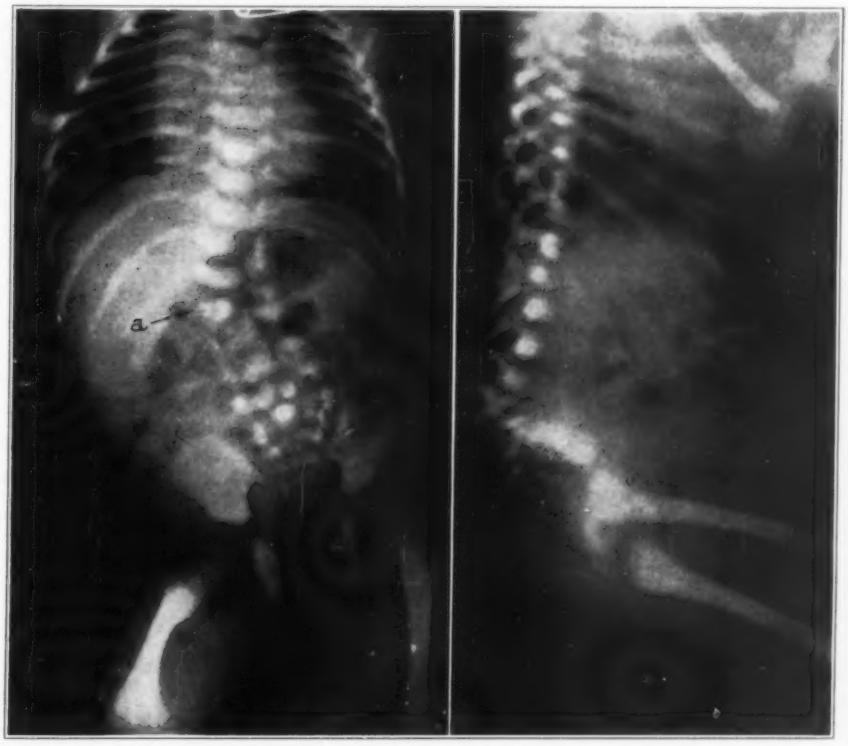

FIG. 3

Case 2. W. H. The anterior-posterior roentgenogram of the spine, taken two weeks after birth of this patient, demonstrates the multiple anomalies and defects which were present. Note the lateral curvature and the asymmetrical development of lateral halves of the bifid vertebral bodies.

The sharply angled lumbar kyphos is well demonstrated in the lateral view of the spine.

FIG. 4-A

Case 2. W. H. The appearance of the spine at the age of sixteen months is quite similar to that noted soon after birth. The first lumbar vertebra *a* is apparently acting as the principle wedge which produces the curvature.

FIG. 4-B

Following the excision of the hemivertebra *a*, the curvature was corrected as shown in the second roentgenogram which was taken two months after operation, February 12, 1932. The tibial grafts *b*, placed in a groove on the sides of the vertebral bodies, are well demonstrated, but the rib grafts *c* on the laminae are not so easily seen.

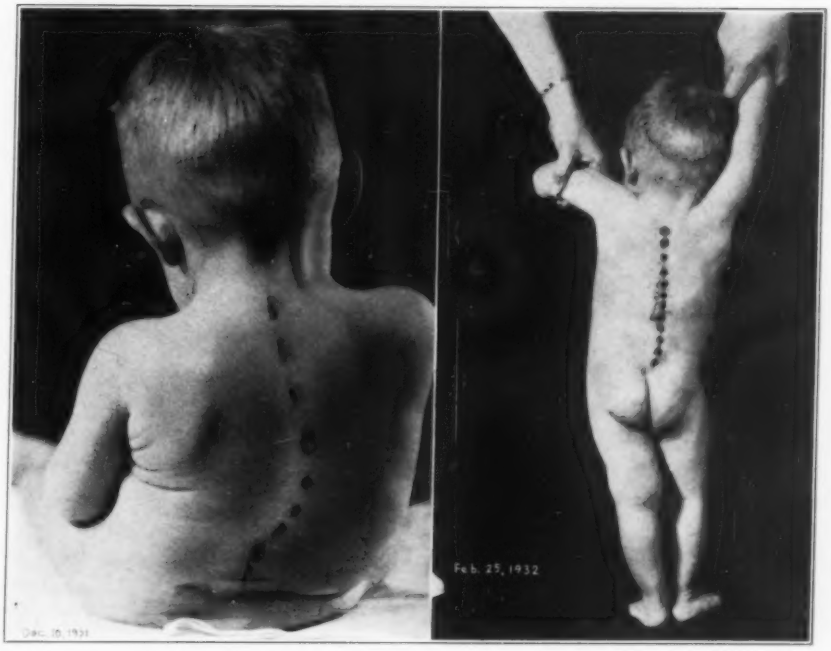

FIG. 5-A FIG. 5-B

Case 2. W. H. Before operation the patient was not able to support himself. The telescoping collapse of the spine when sitting is illustrated in the first photograph. The second photograph, made two months after operation, shows marked improvement in alignment of the tips of the posterior spinous processes.

Using a curved gouge, the right half of the first lumbar vertebra was excised, leaving a cartilage-lined cavity. The corresponding pedicle, articular facet, and lamina were also removed with a bone-biting forceps. It was now possible to close the defect created by removal of this hemivertebra by exerting gentle pressure on the adjacent vertebrae.

An osteoperiosteal bone graft was removed from the left tibia and inserted in a groove gouged in the bodies of the vertebrae from the third lumbar to the twelfth dorsal inclusive. The twelfth rib which had been removed early in the operation was now split lengthwise and placed as a graft on the laminae at the right side of the base of the spinous processes of the eleventh thoracic to the third lumbar vertebrae.

On the fourth postoperative day a body cast was applied, including the head and the left leg. The hinges were placed, anteriorly and posteriorly, so that the axis lay opposite the twelfth dorsal vertebra. By means of a turnbuckle placed on the left side the curvature was corrected.

For fifty-eight days after operation there were no complications. He voided regularly, although he had never been trained, and urine was not collected. Bowel function was normal. On February 10, 1932, he developed an acute retention of the urinary bladder with vomiting and an associated febrile reaction of 38.8 degrees, centigrade. A catheter was passed and 350 cubic centimeters of clear urine were obtained. The phimosis was so marked that the smallest catheter had to be used and it was impossible to retract the foreskin sufficiently to expose any portion of the glans. Following the decompression of the bladder the temperature became normal, the gastric symptoms disappeared, and the patient was entirely comfortable.

A neurological examination revealed no abnormal findings with the exception of the absence of the left ankle jerk. Pressure on the spinal cord from the forced correction or

incarceration of nerve roots in scar or callus would seem to be the logical explanation of the urinary retention.

Upon the advice of the neurological and urological consultants the patient was catheterized twice daily. He is now voiding spontaneously and catheterization has been discontinued. Roentgenograms of February 12, 1932, showed satisfactory correction of the curvature of the spine. The patient is now walking, wearing a full-length body cast.

CONCLUSIONS

1. The standard methods used in the treatment of acquired curvatures of the spine are not adequate for the correction or the prevention of scoliosis which results from congenital anomalies of the spine.

2. Two cases are reported in which nearly all of each hemivertebra was successfully removed with marked correction of the spinal curvature.

3. Since the deformity in these cases is usually progressive, due to the more rapid growth of a number of the asymmetrically developed vertebrae, fusion of the lateral halves of two or more of the vertebral bodies on the convex side of the curvature to check the rate of longitudinal growth would appear to be a rational and justifiable procedure.

4. The fusion of vertebral bodies rather than laminae in the treatment of certain cases of other types of scoliosis in growing children has been suggested.

5. Final judgment of the efficacy of the procedure described cannot be given until many years have elapsed.

REFERENCES

1. Kleinberg, Samuel: Scoliosis. Rotary Lateral Curvature of the Spine. New York, Paul B. Hoeber, Inc., p. 285, 1926.
2. Royle, N. D.: The Operative Removal of an Accessory Vertebra. Med. J. Australia, I, 467, 1928.
3. Codivilla, A.: La Scoliose Congénitale. Gaz. Hebd. de Méd., VI, 637, 1901.
   Sulla Scoliosi Congenita. Arch. di Ortop., XVIII, 65, 1901.
4. Hibbs, R. A., Risser, J. C., and Ferguson, A. B.: Scoliosis Treated by the Fusion Operation. An End-Result Study of Three Hundred and Sixty Cases. J. Bone and Joint Surg., XIII, 91, Jan. 1931.

OSTEO-ARTHRITIS DEFORMANS CONTRASTED WITH OSTEO-ARTHRITIS DEFORMANS JUVENILIS *

BY PROF. F. J. LANG, INNSBRUCK, AUSTRIA

Professor of Pathology and Director of the Pathological-Anatomical Institute of the University of Innsbruck

The comparative study of the adult and juvenile types of osteo-arthritis deformans must be based upon the anatomical and histological changes present in the two types of this disease.

Osteo-arthritis deformans is a chronic non-infectious, proliferative inflammation that leads to a deformity of the joint structures (Fig. 1). The development and presence of marginal exostoses have always been of especial importance for the anatomical as well as the histological diagnosis of arthritis deformans. These marginal exostoses are characteristic and constitute the decisive feature for the diagnosis of this disease (Fig. 2). The exostoses arise as the result of vascularization and ossification which, beginning in the subchondral marrow spaces, invade the overlying non-calcified cartilage. This vascularization and ossification follow the loss of elasticity of the joint cartilage and comprise the first definite diagnostic features of arthritis deformans (Pommer) (Fig. 3).

FIG. 1

Arthritis deformans of a hip joint, showing characteristic lesions. (Macerated specimen.)

These marginal exostoses are not ossified excrescences (Volkmann), or periosteal or perichondrial proliferations or osteophytes (Nichols and Richardson), or periosteal lippings (Kimura, Ziegler); they are (as Pommer maintains) bone formations, that, arising from the

* Read before the College of Physicians of Philadelphia, November 4, 1931 (Mary Scott Newbold Lecture).

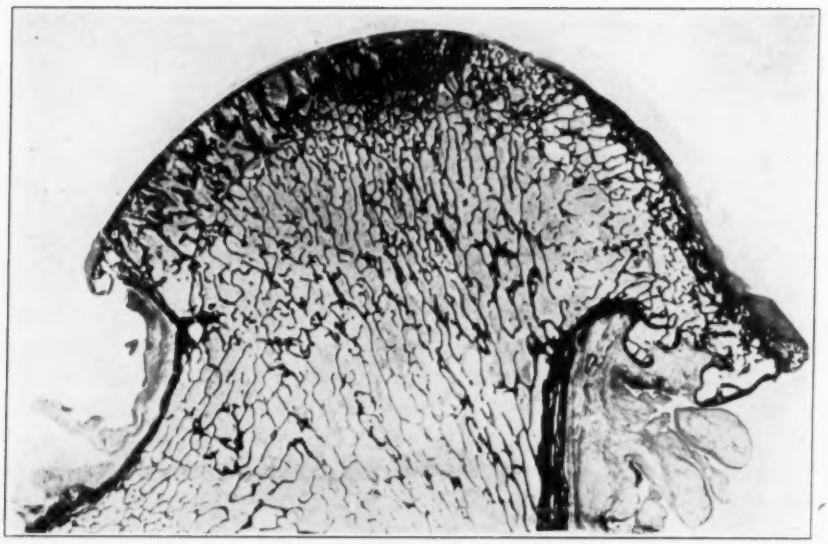

FIG. 2

Head of the femur in arthritis deformans with marginal exostoses. (Microscopic section.)

subchondral marrow tissue, grow out into the joint cartilage. They possess a laminated structure, are united to the spongiosa (Fig. 2), and are usually covered with new cartilage.

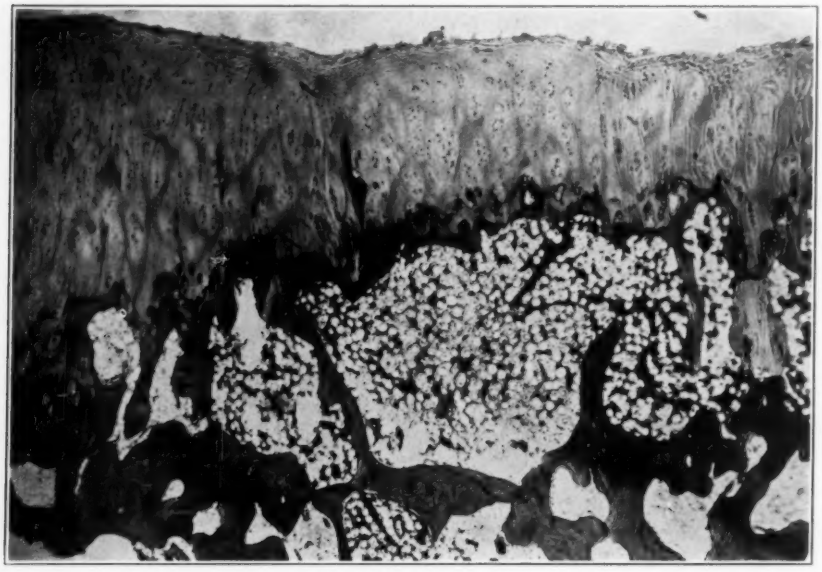

FIG. 3

Vascularization and ossification of the basal cartilage following alterations of the superficial layers of the joint cartilage. (Hip joint of a fifty-three-year-old man.)

The joint cartilage presents various alterations, chief among which are alterations in consistency associated with a splitting of the ground substance (Fig. 3). These alterations disturb and damage the elasticity of the cartilage. These alterations in the physical and structural characteristics of the normal articular cartilage first appear at those sites of normal transition of hyaline cartilage into fibrous cartilage. Anatomically, the most common locations for these changes are about the margins of the fovea and at the junction of the femoral head and neck (Lang, 1924).

FIG. 4

Separated joint cartilage lying deep within the spongiosa. (Arthritis deformans of the hip joint of a fifty-three-year-old man.)

A striking sequel to the vascularization and the ossification of the cartilage is the undermining of the deeper portions of the cartilage. The portions of cartilage thus separated by undermining are often found to lie deep within the spongiosa and in this position mark the site of the original boundary between cartilage and bone (Figs. 3 and 4).

As previously mentioned, the periosteum in general does not take any part in the formation of the marginal exostoses. However, in the more advanced cases of arthritis deformans, periosteal bone proliferations covered by newly formed cartilage can be seen at the insertion of the tendons. The synovial membrane may also be the site of proliferative changes.

Despite the changes in the surface of the cartilage, vascularization and ossification of the basal cartilage layer rarely take place. The cause for this is either that the calcification zone of the joint cartilage is very broad, or the subchondral bone is very compact. The subchondral bone is thus protected against functional and mechanical damage in spite of the loss of elasticity in the overlying cartilage (Pommer). Hence, it is obvious that arthritis deformans is dependent for its development upon the combination of functional and anatomical circumstances.

The layer of cartilage covering large marginal exostoses may be worn away and the underlying bone be exposed and made smooth, giving rise to a hard, highly polished surface (Fig. 5). Frequently in various areas of the polished surfaces small portions of the marrow have become exposed by mechanical irritation and wear. When the degree of irritation and trauma resulting from the impaired mechanical function of the part is considered, it is easily understood why increased bone resorption is found side by side with increased new bone formation. In this union of opposite phenomena is found the explanation of the characteristic deformities of the joints in arthritis deformans.

In the more advanced cases of this disease, one can find, especially in the subchondral bone and along the junction between cartilage and bone, callus and resorptive tissue proliferations. This callus formation arises as a result of the splitting and cracking of the bone and of the cartilage. These reactive processes make clear the striking picture of porosity and condensation that is so obvious in the macerated specimen.

Microscopic cysts are likewise found in the exposed subchondral marrow spaces (Fig. 5). These cysts are either the result of encapsulation of hemorrhages or of areas of detritus. Thus is disproved the theory of Kimura and Ziegler that the cause of arthritis deformans lies in regressive changes in the subchondral bone (Pommer). In far advanced arthritis deformans, the so called cartilage nodules are observed; these are situated in the marrow spaces of the spongy bone beneath the polished joint surface. According to Pommer and Lang (1924), the cartilage nodules can originate in two ways: first, as callus resulting from microscopic fractures, and, second, as fragments of joint cartilage that are broken off and transported as emboli along the capillaries and lymph vessels and grow where they lodge.

With the knowledge of the local origin of the various reactive and progressive changes in arthritis deformans, it can be understood how atrophy, caused by age and inactivity, occurs at the same time that these other changes are taking place. Thus, not only sclerotic but also atrophic polished areas are observed.

Considering the above described findings and their explanations, the distinction between the atrophic and the hypertrophic or between the degenerative and the hyperplastic types of arthritis deformans is not necessary.

According to Pommer and Beitzke, the varieties of arthritis deformans present no distinctive differences; they are but gradations of a process that is uniform as regards its origin. Naturally, in the explanation of these differences, individual variations must be considered. These variations have their origin in the anatomical structure, in the functional requirements, and in the effacement of the part by use (Lang, 1924).

A distinction between the chondral and osseous forms of arthritis deformans is also unnecessary. For, in the final analysis, it is the damage

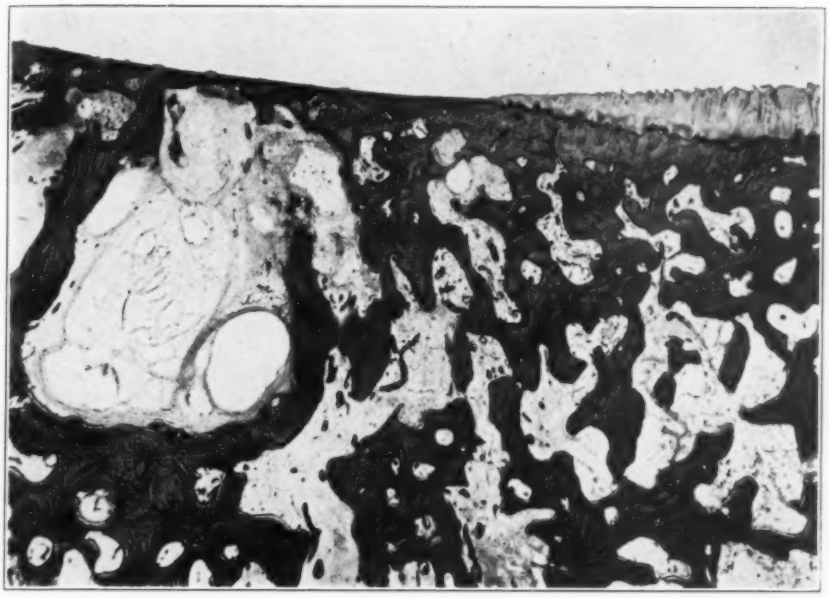

FIG. 5

Polished articular bone surface with cyst formation in the underlying spongiosa. (Arthritis deformans of the hip joint of a fifty-three-year-old man.)

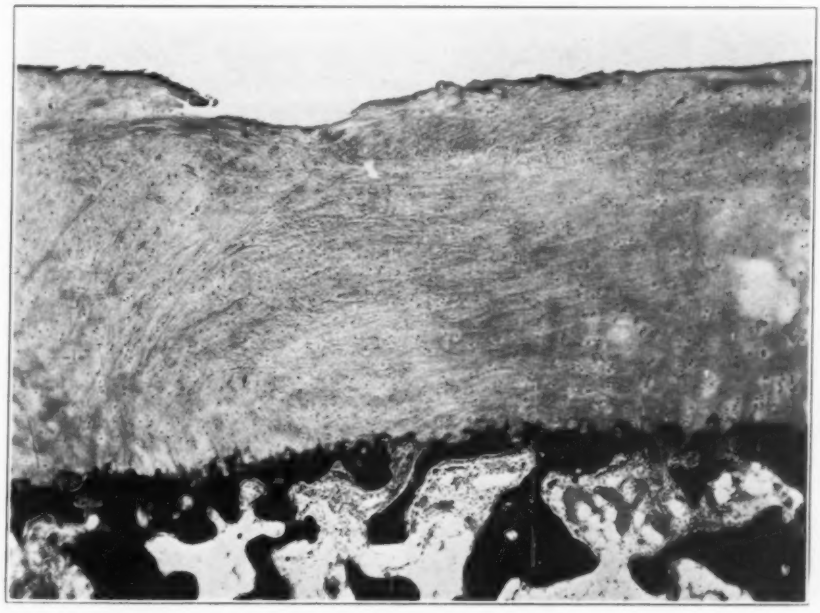

FIG. 6

Head of the femur of a nine-year-old girl with arthritis deformans juvenilis. Note the loss of substance in the articular surface of the cartilage.

FIG. 7

Arthritis deformans juvenilis (Legg's disease) in a nine-year-old girl with formation of marginal exostoses and mushrooming of the femoral head.

to the cartilage with its resultant loss of elasticity that is responsible for the origin of the disease (Lang, 1931).

In spite of the numerous anatomical and pathological investigations as to the nature of its origin, arthritis deformans has more recently been called, from the clinical and roentgenological points of view, an "arthrosis". The designation of arthritis deformans as "arthrosis" is to be avoided, as the termination "osis" is used in pathology to indicate changes of a degenerative nature. Thus, for example, nephrosis indicates any degenerative change in the kidney, and nephritis, an inflammatory process. It is asserted that constitutional influences have to be considered in the development of arthritis deformans, and, therefore, the designation "arthrosis" is preferable to "arthritis". This argument, however, is not sound. These considerations are important for every inflammatory process, regardless of what organ or structure is the site of the inflammation. Constitutional influences can, nevertheless, affect the type, the intensity, the extension, and the outcome of an inflammatory process (Lang, 1931). It is absolutely necessary to keep in mind the histological distinction between inflammatory and degenerative processes. This distinction is not superfluous and is of value since inflammatory and degenerative processes frequently occur side by side (Lang, 1931). Under all conditions, *the character of arthritis deformans is a chronic, proliferative, non-infectious inflammation of the joint* and, therefore, the only justifiable designation of this process is "arthritis".

Regarding the *causes of arthritis deformans*, it must first of all be admitted that a direct relationship can exist between arthritic changes and certain systemic diseases. But vascular changes, especially arteriosclerosis, are not the main cause of arthritis deformans. The vessel changes that are sometimes seen are generally either independent of or secondary to the inflammation or localized circulatory disturbances, such as occur in the advanced cases of arthritis deformans. Likewise, there is no proof that under natural and non-experimental conditions the cause of primary arthritis deformans is due to necrotic changes of the cartilage. Furthermore, there is no confirmation of the view that regressive and atrophic changes of the subchondral bone are of importance in the development of this disease.

The only satisfactory explanation for arthritis deformans is found in the functional theory of Pommer. This theory presupposes that the joint cartilage, through its elasticity, protects the subchondral bone and its marrow from the irregular, localized effects of impacts, jarrings, and pressures arising from normal function. Following damage to the joint cartilage, with subsequent loss of its elasticity, the mechanical effects of normal joint function become more or less localized and are transmitted unmodified to the joint structure resulting in a reactive vascularization and ossification of the cartilage.

The damage to the joint cartilage arises: first, from unequally distributed or violent strains,—for example, of heavy labor, of bent posture, or of those occurring in tabes dorsalis in which the pain sensibility is lost; second, through diseases of the joint cartilage itself; third, through diseases of the joint capsule, the synovial membrane, and the subchondral bone; and, fourth, through endogenous metabolic and endocrine influences (Lang, 1931).

The recognition of the functional and mechanical importance of the joint cartilage as the protective covering of the subchondral bone (Roux) demands that the mechanical and functional damages to the joint cartilage be adjudged the most important factor, not only for the pathogenesis, but also as the etiological factor of arthritis deformans. An especial confirmation for the functional theory of arthritis deformans is the fact that this disease is frequently found in certain occupations. Sufficient proof for this statement is given in the literature.

R. Beneke has pointed out the possible sequelae of old traumatic changes. I was able to confirm his idea by my studies of juvenile joints, in which I found evidences of the end results of more or less extensive traumatic changes (Lang, 1922, 1924). By these studies, this theory is substantiated: that arthritis deformans is already initiated in the early years of life and, therefore, the disease has to be considered as a consequence of trauma carried over from childhood and adolescence. When the after effects of trauma in early life are considered, it becomes evident that in the sequelae of chronic, oft-repeated functional traumata lies the etiology of arthritis deformans of the adult (Lang, 1931).

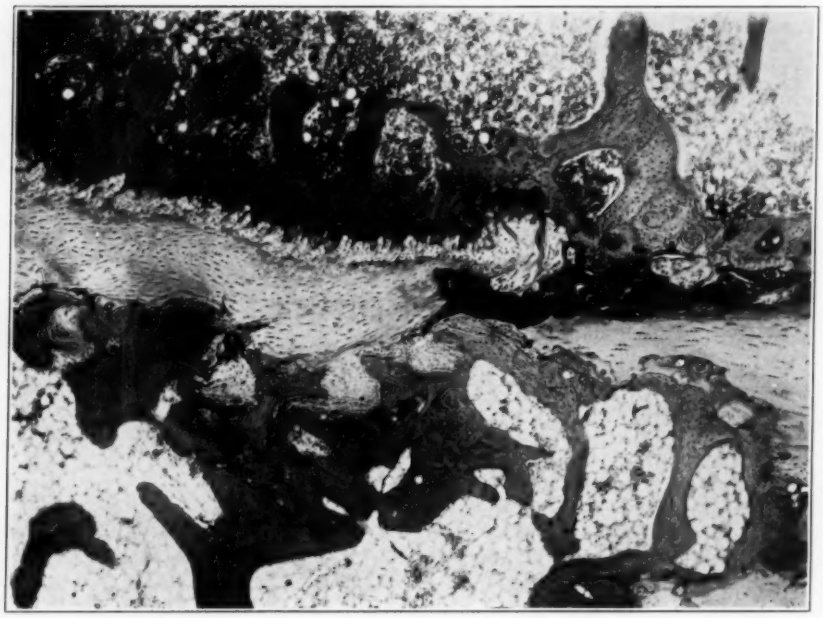

FIG. 8

Fissure formation in the cartilage of the epiphyseal line. (Legg's disease, nine-year-old girl.)

I was able to investigate the juvenile form of arthritis deformans in Perthes-Legg-Calvé's disease of the hip joint, Köhler's disease of the first and second metatarsal bones, and other so called "aseptic necroses" (Lang, 1922, 1924, 1931). In these diseases the characteristic diagnostic features of arthritis deformans were present,—namely: changes of the joint cartilage, vascularization and ossification of the cartilage, and marginal exostoses (Figs. 6 and 7).

In the juvenile type of arthritis deformans the epiphyseal zone presents changes typical of those found in arthritis deformans of adults. As a sequel to these changes, cessation of ossification occurs in the involved portion of the epiphyseal line. In the cases of juvenile arthritis deformans are found striking examples of fissure formations, splintering and fragmentation of cartilage, of subchondral bone, and of the bone and cartilage along the epiphyseal line (Fig. 8). These changes stimulate callus formation with the production of new cartilage and bone so characteristic of juvenile arthritis deformans. The splintering and fissurations are found along the bone cartilage juncture; their lines of direction are in part parallel with and in part at right angles to the lines of strains (Fig. 8).

The behavior of the epiphyseal zone and the size, position, and structure of the epiphyseal bone determine whether adjustment and distribution of the vibrations of impacts and jarrings are possible or whether

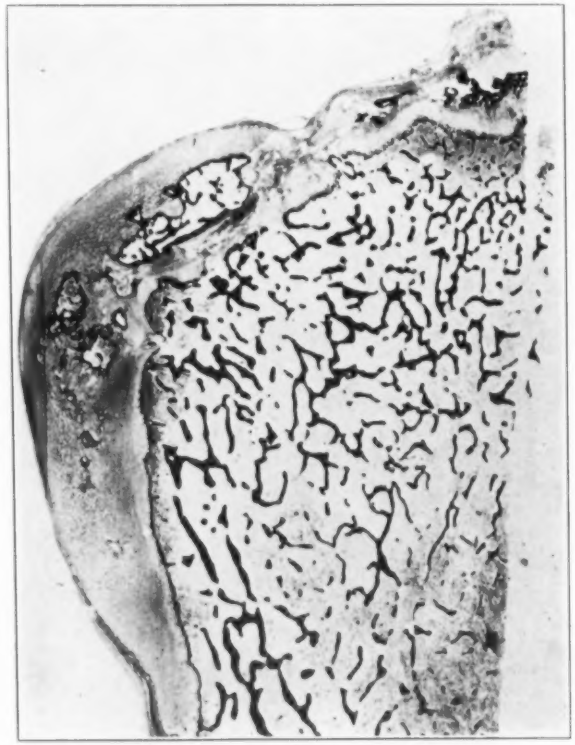

FIG. 9

Section from the head of the femur in Legg's disease with malformation of ossification.

FIG. 10

Synchondrosis of the acetabular cavity of a twelve-year-old girl with extensive traumatic changes along the epiphyseal line and callus formation.

splintering and fragmentation with displacement of the fragments will occur (Lang, 1931). More or less extensive hemorrhage with subsequent hemosiderin deposits and blood-cyst formation complete the picture of previous trauma.

From my studies it is evident that functional traumata are *determining factors* for the origin of juvenile arthritis deformans. The continuous effects of this trauma are responsible for the insidious character of juvenile arthritis deformans.

The following two cases of Perthes' disease are illustrative of this point.

The first patient was a normal twenty-two-year-old male who fell from a ladder, injuring his right thigh. X-ray examination showed an oblique, incomplete, subtrochanteric fracture. After six weeks in a plaster cast the patient was discharged with the x-ray examination at this time showing complete healing of the fracture. Two years later a pronounced flattening of the femur head was roentgenologically visible which, three and a half years after the injury, was far advanced. At this time, because of pain and limitation of motion, the joint was opened and a mushroom-shaped femoral head removed. This case is clarified only by postulating damages to the joint cartilage and—what is especially important—fissure formations in the subchondral bone with a consequent disturbance of the structural equilibrium, damages which were, of course, invisible in the first two x-ray films.

After six weeks of rest these areas were subjected to continued functional traumata with a resulting disturbance of the processes of reconstruction. The final microscopic picture shows tiny pseudarthroses lined by new cartilage, areas of osteitis fibrosa with islands of splintered and pulverized bone, cysts containing hemorrhages and débris, and all the characteristic signs of arthritis deformans.

The second patient was a fifteen-year-old boy who developed Perthes' disease following a gunshot wound of the soft parts about his right hip. Neither bone nor joint structures were involved. X-rays were taken immediately and at periods of nine and eleven months after the injury (Just). The first roentgenological examination failed to show any damage to bone or joint. In the examination made nine months after injury there existed well advanced changes in the femoral head characteristic of Legg-Perthes' disease. These changes were more marked in the last x-ray. Here, as a result of a relatively mild localized indirect trauma (as compared with the first case cited), there developed a characteristic deformation of the femoral head.

These two cases are representative of latent bone changes resulting from: first, severe direct trauma and, second, from relatively mild indirect trauma.

The bilateral, symmetrical type of Legg's disease of the hip joint is exceptional. When the disease is bilateral it is usually found that there existed a developmental malformation of both femoral epiphyses. It is well recognized that a developmental malformation of an epiphysis predisposes that structure to damage by relatively mild functional and actual traumata (Fig. 9).

The importance of trauma for the origin of juvenile arthritis deformans is in no wise lessened because no history of injuries can be elicited. In comparative studies, I was able to demonstrate histologically, in many cases giving a negative history for trauma, more or less severe traumatic changes with their sequelae (Lang, 1924) (Fig. 10).

When there is a history of trauma without subjective or objective symptoms being present immediately after the injury, one must consider the sequelae that may be found at a later date. An example of this is the post-traumatic atrophy of the vertebrae described by Kümmell. This atrophy may lead to almost complete disappearance and collapse of the body of a vertebra but it does not become evident until some time after the original injury.

In estimating the importance of trauma, there can be no doubt that mechanical damage to a joint, due to excessive athletic activity in early life, will lead to arthritis deformans (Lang, 1931).

In conclusion, it is evident that there are no fundamental differences between arthritis deformans of the adult and juvenile arthritis deformans. Both types of the disease originate after damage to the articular and joint cartilage with subsequent loss of its elasticity. This loss of elasticity removes the protection that the normal cartilage affords to the subchondral bone against functional and mechanical influences.

As a causative agent for arthritis deformans in adults, the damage to the cartilage, resulting from excessive strains, is of primary importance. In juvenile arthritis deformans, direct and indirect traumatic damages to the cartilage and, especially, to the osteochondral junction are held responsible. The decisive factor for the progressive course of both types of arthritis deformans is the action of the functional requirements which, acting as a source of constant irritation, forms *the basis for the progressive character of the disease.*

REFERENCES

Beitzke H.: Über die Sogen. Arthritis Deformans Atrophica. Ztschr. f. Klin. Med., LXXIV, 215, 1911–12.

Beneke, R.: Zur Lehre von der Spondylitis Deformans. Beitr. z. Wiss. Med. Festschr. d. LXIX. Vers. Deutscher Naturforscher und Ärzte, Dangeboten vom Herzogl. Braunschweig, Staatsministerium, p. 109, 1897.

Just, E.: Zur Aetiologie der Osteochondritis Coxae Juvenilis Deformans. Wiener Klin. Wchnschr., XLIV, 889, 1931.

Kimura, K.: Histologische Untersuchungen über Knochenatrophie und Deren Folgen, Coxa Vara, Ostitis und Arthritis Deformans. Zieglers Beitr. z. Path. Anat. u. z. Allg. Path., XXVII, 225, 591, 1900.

Lang, F. J.: Mikroskopische Befunde bei Juveniler Arthritis Deformans. Virchows Arch. f. Path. Anat. CCXXXIX, 76, 1922.

Zur Kenntnis der Veränderungen der Hüftpfanne bei Arthritis Deformans. Virchows Arch. f. Path. Anat., CCLII, 578, 1924.

Die Osteo-Arthritis Deformans. Wiener Klin. Wchnschr., XLIV, 861, 1931.

Nichols, E. H. and Richardson, F. L.: Arthritis Deformans. J. Med. Research, XXI (New Series XVI), 149, 1909.

Pommer, G.: Mikroskopische Befunde bei Arthritis Deformans. Denkschr. der Kaiserl. Akad. d. Wiss. Wien. Math. Naturw. Klasse, LXXXIX, 65, 1914.

Volkmann, R.: Verletzungen und Krankheiten der Bewegungsorgane. Handbuch der Allg. u. Spec. Chirurgie, II, Pt. 2. Erlangen, 1865.

Ziegler, E.: Über die Subchondralen Veränderungen der Knochen bei Arthritis Deformans und über Knochencysten. Virchows Arch. f. Path. Anat., LXX, 502, 1877.

OPERATIVE TREATMENT OF CHRONIC DISLOCATION OF THE PERONEAL TENDONS

BY ELLIS JONES, M.D., LOS ANGELES, CALIFORNIA

Traumatic dislocation of the peroneal tendons is relatively rare, but displacement of one or both of the tendons, when it does occur, causes serious disability. While permanent displacement of these tendons anterior to the malleolus not uncommonly follows as the result of paralytic deformity, it gives rise to no symptoms and requires no treatment other than the correction of the talipes calcaneus, which usually accompanies it.

Traumatic or habitual displacement of one or both of the tendons demands operative interference, since the superior retinaculum is invariably ruptured, and with rupture of the retinaculum there remains no structure capable of retaining the tendons in their normal position. Edwards [1] and others have shown that the peroneal groove on the posterior surface of the lateral malleolus when present is usually very shallow and that the lateral ridge when present, and even when augmented by cartilage, is not of sufficient proportions to retain the tendons in the groove. Edwards has found that seven per cent. of the fibulae examined were actually convex transversely in this region, and it would seem that this type would be especially prone to dislocation of the tendons.

Various types of operations are described in the literature. In chronic cases, Whitman [2] advises suturing the displaced sheath in its normal position, or deepening the peroneal groove, or, if the displacement appears to be due to a shortening of the tendon, he suggests that the tendon be divided and lengthened in the usual manner. Retention of the displaced tendons by the formation of osteoperiosteal flaps, fashioned from the external malleolus, looped around the tendon, and resutured to the malleolus posteriorly, is the method which has been used successfully by Kraske [3] and Kramer [4] in an effort to reconstruct a retinaculum of sufficient strength to insure retention. An artificial retinaculum has been similarly reconstructed by Kraske from osteoperiosteal tissue freed from the calcaneum and external malleolus. Albert [5] and Lannelongue [6] believe that the luxation is due to an abnormal flattening of the malleolus. Albert deepened the groove. Lannelongue sought to heighten the eminence surrounding the groove by means of a periosteal bone flap from the malleolus. In Lannelongue's case a well-developed crista formed, easily palpable on the malleolus, and a good functional end result was obtained. König [7] reported a favorable result from the use of a periosteal bone flap used as a retention loop around the tendons. More recently Kelly [8] reported two successful end results following the use of a bone graft, employed to form a new and capable external lip to the peroneal groove, which effectively prevented the tendons from slipping forward. Lexer [9] utilized the palmaris longus, inserting this tendon into the external mal-

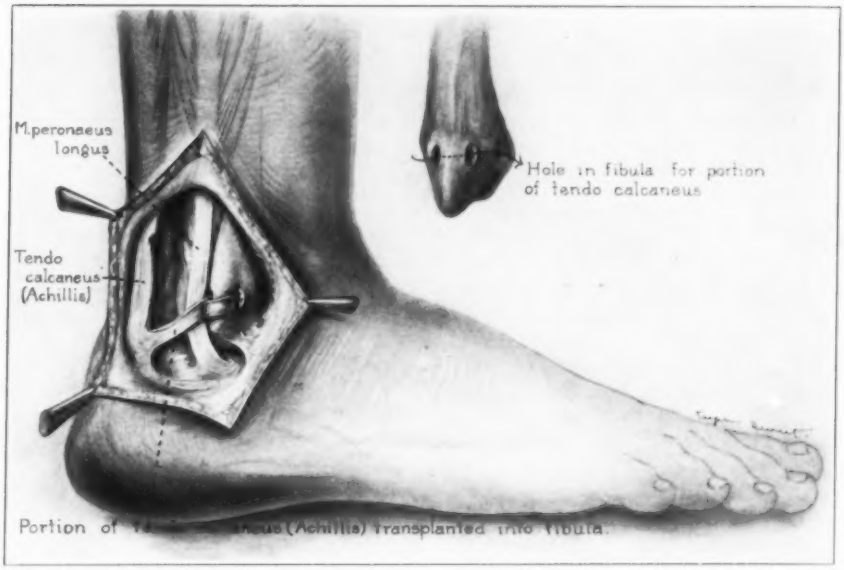

FIG. 1

leolus in the form of a loop encircling the peroneal tendons and maintaining reduction. Estor [10] recommended the reconstruction of a capable retromalleolar groove and the temporary use of a silver wire to maintain reduction. Hanson [11] employed a periosteoplasty, loosening a flap of periosteum from the fibula and a similar flap from the calcaneum, suturing both flaps together over the peroneal tendons.

The writer presents the following method of tenoplasty, by which reduction of the dislocated tendons is maintained by a tendon slip fashioned from the tendo achillis at its calcaneal insertion and implanted into the external malleolus, the transplanted tendon acting as a thoroughly adequate substitute for the ruptured retinaculum.

OPERATION

The peroneus longus tendons are exposed by a straight incision, two inches in length, extending downward directly behind the external malleolus. The tendo achillis is exposed and a tendon slip, two and one-half inches in length and approximately one-fourth inch in width, is freed from above downward and left attached at its calcaneal insertion. The peroneal tendons in their sheath are firmly retracted. A hole is drilled transversely through the fibula one inch above the tip of the malleolus, and the tendon slip is passed from behind forward through the drill hole, looped posteriorly, and sutured with twenty-day chromic suture both to the periosteum of the fibula and to the tendon slip itself, while the foot is held strongly dorsiflexed in full supination. The peroneal sheath is not opened. The skin is closed, and the wound is dressed in the usual manner. A short plaster cast is applied with the foot in moderate supination

and ninety degrees of flexion. The plaster cast is changed at the end of two weeks, a short cast being reapplied with a walking stirrup incorporated to permit guarded weight-bearing. All fixation is removed at the end of six weeks, at which time the patient is permitted full activity.

CASE REPORT

C. L., aged twenty-two years, student, was examined on December 18, 1931, because of persistent pain and disability in the right foot and ankle joint. The patient gave a history of a football injury three years previously, at which time he felt the tendon on the outer side of his foot slip over the bone. He was able to push the tendon back and obtained temporary relief from ankle strapping and support, but was acutely disabled for one month. He was unable to continue at football. He attempted collegiate football this year, wearing a tight bandage, but complained that he was immediately disabled whenever the tendon slipped forward and that the tendency to slipping under slight effort was increasing. He stated, "I never know when it is going to slip and throw me". The patient was submitted to operation as above described on December 19, 1931. At operation the sheath was found intact. The superior retinaculum was entirely absent. No gross deformity of the fibula was evident. All fixation was removed on January 28, 1932, and the patient was permitted full activity. Examination on February 10, 1932, showed a normal range of motion with excellent stability of the ankle joint. On March 15, 1932, the patient stated that he had reported for spring football and was engaging in full activity and that the ankle was symptomless.

CONCLUSION

The operation here described prevents redislocation of the peroneal tendons by furnishing a capable substitute for a retinaculum and fulfills all the physiological, anatomical, and mechanical requirements.

BIBLIOGRAPHY

1. Edwards, M. E.: The Relations of the Peroneal Tendons to the Fibula, Calcaneus, and Cuboideum. Am. J. Anat., XLII, 213, 1928.
2. Whitman, Royal: A Treatise on Orthopaedic Surgery. Ed. 6. Philadelphia and New York, Lea and Febiger, 1919.
3. Kraske: Über die Luxation der Peroneussehnen. Zentralbl. f. Chir., XXII, 569, 1895.
4. Kramer, W.: Über die Luxation der Peroneussehnen. Zentralbl. f. Chir., XXII, 641, 1895.
5. Albert: Quoted by Estor [10].
6. Lannelongue: Quoted by Estor [10].
7. König, Fritz: Operation einer Doppelseitigen Luxation der Peronealsehnen. Deutsche Med. Wchnschr., XXIV, Vereins-Beilage, 132, 1898.
8. Kelly, R. E.: An Operation for the Chronic Dislocation of the Peroneal Tendons. British J. Surg., VII, 502, 1920.
9. Lexer: Quoted by Estor [10].
10. Estor, E. et Aimes, A.: La Luxation Congénitale des Tendons des Muscles Péroniers Latéraux. Rev. d'Orthop., X, 1, 1923.
11. Hanson, R.: Operative Treatment of Case of Habitual Luxation of Peroneal Tendons. Acta Orthop. Scandinavica, I, 276, 1930.

ECHINOCOCCUS DISEASE OF BONE

Report of Two Cases Involving the Pelvic Girdle*

BY BRADLEY L. COLEY, M.D., NEW YORK, N. Y.

Hydatid disease of the skeletal system is an extremely rare bone lesion. Dew[1] and Hsieh[2] have found that it is present in less than one per cent. of all cases. Its frequency has been given by other observers as follows: Thomas[3], one and six-tenths per cent.; Vinas[4], one and twenty-nine hundredths per cent.; Mills[5], one per cent.; Dévé[6], nine-tenths per cent.; Vegas and Cranwell[7], fifty-nine hundredths per cent. The rarity of reports of bone hydatid occurring in the American literature justifies recording two cases which were seen and studied at Memorial Hospital.

Case 1. R. R., aged twenty-six, was born in Southern Italy in 1905 and migrated to the United States in 1921. Since then he has lived in Newark, New Jersey. His grandfather, both parents, wife, two children, five sisters and brothers are apparently free from disease. He is a tailor and there has been no association with dogs or other animals. He was in excellent health up to Christmas, 1928, when he complained of a pain in the right knee, to which little notice was paid until April, 1929, when he was admitted to St. Michael's Hospital, Newark, complaining of severe pain in the right knee and limitation of motion in the right hip joint. Examination at that time showed a well developed and nourished young Italian in good physical condition, not acutely ill, with an intra-abdominal mass the size of an egg in the hollow of the right ilium and, attached to it, a small mass deep in Scarpa's triangle on the right side. There was limitation of motion in the right hip joint in all directions. Biopsy from the crest of the ilium failed to show pathology. Because the tumor clinically resembled osteogenic sarcoma, the patient received seven injections of Coley's toxins and was then referred to Memorial Hospital, where, in September, 1929, he was admitted to the Bone Tumor Department.

Physical examination on admission was essentially as noted above. There was no gross deformity of the right ilium; Wassermann, urine, and blood studies were all normal; eosinophils were one per cent. X-ray report on September 30 showed: "A process of extensive irregular decalcification with areas of increased density throughout the ilium; no gross bone destruction or production; films of lungs negative for metastases or tuberculosis".

No x-ray diagnosis was ventured. Clinically it was considered to be an osteogenic sarcoma and the patient received eighteen injections of Coley's toxins and 177,000 hours of radium pack at a distance of ten centimeters, over a period of eight months. Little change was noted in the physical condition of the patient, though the series of films showed progressive decalcification in very irregular fashion. Biopsy by aspiration was attempted on May 14, 1930, but the aspiration failed to establish the diagnosis.

On July 17, 1930, there appeared several ounces of yellow, necrotic material from the mass in the right groin, issuing from a sinus at the site of the previous aspiration. Microscopic examination showed this material was pus and the sinus failed to heal. Operation for further drainage on September 6, 1930, produced material, which was regarded by the pathologist, Dr. Stewart, as suspicious of echinococcus disease.

On October 30, 1930, an abscess which had been slowly developing over the right sacro-iliac region was incised and at this time a number of typical daughter cysts were obtained and a definite diagnosis made. The ilium was found to be a hollow shell with

* From the Bone Tumor Department, Memorial Hospital, New York.

many small fragments of bone loosely held together. A number of these were free sequestra and were lifted out of the wound.

Patient is at present free of other demonstrable evidence of echinococcus disease; there is no fever, jaundice, or enlarged liver. White blood count is 9,300; red blood count 4,500,000; hemoglobin eighty-five per cent. There has been severe pain in the right hip joint and leg, but at present the patient is in fair condition. However, the latest films of the right ilium show almost total destruction of this bone, and involvement of the fifth lumbar vertebra, and telescoping of the right femoral head into the hollow of the sacrum. There is no swelling or tumor of the soft parts. Although the entire right lower extremity is functionally useless, the patient has been able to get about fairly well on crutches. There has been a marked rotation of the pelvis on the unaffected side.

Case 2. A male, aged fifty-eight, by occupation a carpenter, who was born in Russia and had lived there for about twenty-five years, was admitted to the Memorial Hospital,

Fig. 1

Case 1. Roentgenographic appearance of right ilium, February 5, 1930, showing extensive involvement which includes the right wing of the sacrum.

October 1, 1926, with a history which had begun five years ago when the patient fell, striking his sacrococcygeal region. Immediately thereafter he experienced severe pain in the back, radiating down the lower extremities to the knees. Walking was difficult. Although these symptoms had persisted more or less constantly since onset, there had been an increase in their severity during the few months prior to admission. He was referred to the Memorial Hospital from the Neurological Service at Bellevue Hospital, where he was found to have extramedullary involvement of the sacral roots; and where roentgenograms of the sacrum were said to show productive osteo-arthritic changes of the lumbar spine, and a polycystic degenerative process involving the left ala of the sacrum, and characteristic of giant-cell sarcoma.

The patient was under the care of Dr. William S. Stone, then Clinical Director of Memorial Hospital, with whose permission this case report is included.

FIG. 2

Case 1. December 8, 1930. Showing extension of process after ten-months' interval as compared with Fig. 1. Note luxation in head due to destruction of acetabulum.

Physical examination on admission: Patient walked with a slightly stooped attitude. There was marked rigidity of the lower spine with little motion in any direction. Rectal examination was negative except for some increased firmness of the prostate. Roentgenograms made October 1, 1926, were reported by Dr. Herendeen as showing destruction of the left wing of the sacrum all the way to the sacro-iliac synchondrosis, with some increased density along the line of the former articulation; pelvic bones showed no atrophy, as in tuberculosis; marked calcification in the arteries of the pelvis and thighs was evident.

One week later patient was shown at the Memorial Hospital conference. No definite diagnosis was made, but high voltage x-ray treatment was ordered immediately. Patient continued to have severe pain, which radiated down the left leg to the foot (nerve pressure?). His general condition remained satisfactory; no palpable tumor could be felt.

On March 4, 1927, further x-rays were made, report of which was: "New formed bone not apparent; probably an osteochondrosarcoma".

On September 15, 1927, more x-rays were taken and the report was: "No extension or change in the tumor".

On December 15, 1927, patient was examined by Dr. Hyslop, attending neurologist, who made the following report:

"This patient I saw at Bellevue over a year ago. At that time he was advised to try radiation. It has not helped. In view of lack of extension of the tumor process and absence of new neurological signs, I think chordotomy is indicated in this case."

The patient disappeared temporarily from observation and the next note, dated March 4, 1929, showed that the patient had been at Mt. Clemens, Michigan, taking baths. No further radiation had been given. Pain had continued, but general condition was well maintained. The area where the radiation had been given over the back of the pelvis was leathery, depressed, and showed beginning telangiectasis. X-ray films made at this time were reported to show some improvement and the patient was shown at conference March 7, 1929, at which time Dr. Stone advised continued observation.

On April 18, 1929, another neurological examination was made by Dr. Hyslop, who stated: "Pain continues; is located in right knee and left foot. Left toes and ankle cannot be extended. Cannot lie down. No urinary disturbances. Constipated. Unable to sleep because of pain. Examination shows knee and ankle jerks absent. Vibration absent in right leg and left ankle. Pin and touch sensation reduced in the fifth lumbar and first sacral segment distribution on the left. There is weakness in flexion of the left foot and ankle. Chordotomy recommended."

At this time the case was referred to Dr. Stone and Dr. Craver and the patient was admitted for chordotomy, which was performed by Dr. Stookey May 1, 1929. Following chordotomy, patient was unable to void and was catheterized every twelve hours. Six days later he became incontinent. Nine days after operation sutures were removed and the wound was healed *per primum*. Patient was dribbling involuntarily. No sensation in the bladder region. Bladder became infected. Permanent catheter inserted with bladder irrigations three times a day. Eighteen days after operation, because of daily elevation of temperature from 103 to 104.6 degrees, patient was seen by Dr. Dean, associate on the Urological Service. Dr. Dean believed the fever was due to obstruction between bladder and kidneys, because relief of the bladder obstruction had not been followed by amelioration of the condition; at cystoscopy he found an inflamed and oedematous bladder, but was unable to pass the catheter more than one and one-half centimeters up either ureteral orifice. Intravenous indigo carmine did not appear from either side in twenty-five minutes.

Patient gradually declined during the following month; was in severe pain with abdomen distended and tender on deep palpation; became irresponsive; took nothing by mouth; drained but slightly from the bladder and, on June 7, 1929, developed oedema of the lungs, Cheyne-Stokes' respiration, and died.

At autopsy the following findings were noted:

1. Echinococcus cyst of ilium, sacrum, and lungs.
2. Acute catarrhal cystitis, ureteritis.
3. Pyelonephritis.
4. Congestion of the liver.
5. Secondary infection with deep abscess, pelvis to thighs.
6. Acute splenic tumor.
7. Small infarcts of spleen.
8. Vegetative endocarditis of aortic valve.
9. Arteriosclerosis.
10. Decubitus chronicus.

Microscopic examination confirmed the gross. The renal lesion showed pyelitis, slight vascular nephritis, marked cloudy swelling, no definite ascending infection. Echinococcus cyst in the lung was old and sterile. The cysts in the bone were active.

INCIDENCE

Hydatid disease, while relatively uncommon in the United States, has received intensive study in countries where it is of frequent occurrence. Among those who have contributed much to our knowledge of this disease may be mentioned Dew[1] of Australia, whose work published in 1928 is one of the most complete sources of information published in recent years. Loucks[8], in 1930, presented a review and reported all cases of echino-

FIG. 3

Case 2. March 24, 1929. Showing roentgenographic appearance of left half of sacrum.

coccus disease from Northern China (of which there were only sixteen). One of these cases was made the subject of a further report by Hsieh[2], since it represented the first case of bone involvement recorded in China. The rarity of bone involvement is apparent from the fact that in 1917 Walker and Cummins[9] were able to find only eighty-eight cases in a survey of the literature and, since then, less than thirty scattered cases have been added.

Osseous hydatid, according to Loucks, may in most countries be considered a surgical curiosity. It occurs in about one per cent. of all reported cases. He expresses surprise at the scant attention which this phase of the disease has received in the literature and textbooks, especially when the puzzling and often striking changes, which may be wrought in bone by the parasite, are considered. In North America but three cases of osseous hydatid have been reported,—*i.e.*, Lyon[10] in 1902, Walker and Cummins[9] in 1917, and Hines[11] in 1926. A summary of these cases follows:

Lyon[10], in 1902, presented the third statistical study of hydatid disease in America, the first having been published by Osler[12] in 1882, in which sixty-one cases from the United States and Canada were collected, and the second by Sommer[13], in 1895 and 1896, who assembled 100 cases from the United States. The statistics of Osler[12] and Sommer[13] together include 110 cases. To these, Lyon[10] added 135, thus comprising a total of 241 cases occurring in the United States and Canada up to 1902.

Of these 241 cases, bone involvement was mentioned but once (Case 161). This patient (reported by Woods in 1899)[14] had a small cyst in the head of left humerus in addition to a large cyst of the liver extending through the diaphragm into the right pleural cavity. Daughter cysts, scolices and hooklets were found.

On studying the brief notes on Lyon's collection of cases, however, it would appear that Case 195 might have been an example of echinococcus disease of the left ilium. The note states that the cyst was in the left iliac region, apparently post-peritoneal. In Case 193, the location of the cyst was mentioned as being in the arm above the elbow, but here no mention of bone involvement was made. It must be remembered that this series of collected cases was made prior to the advent of the widespread use of the roentgen ray as an aid in diagnosis.

Walker and Cummins reported a case of a Greek, aged thirty-one, first seen in July, 1915, with symptoms of aching pains in the upper third of the left tibia of three years' duration. The pains were paroxysmal in character and were worse at night. There was no history of trauma and no suspicious contact with dogs. A roentgenogram revealed a cystic condition of the tibia through its upper third. Wassermann test was negative. At operation the tibia was exposed and curetted. Atrophy of the bone and enlargement of the medullary cavity were noted. Many cysts of various sizes were found throughout two-thirds of the length of the bone. No scolices or hooklets were found, but a well defined lami-

FIG. 4

Case 2. Photograph of gross specimen (autopsy) showing echinococcus involvement of sacrum.

nation of the cystic areas was observed. Some months later patient again complained of pain in the sinus, which had existed since the first operation. This was again opened, curetted, and packed. Four months thereafter he complained of increased pain and, as the wound was being swabbed out, a collapsed cyst appeared. The curet withdrew another intact cyst. Nine months after the first operation a more radical procedure was undertaken and, at this time, a number of small cysts were found. Sixteen months after the first admission the leg was healed.

Hines, in 1926, reported a case of a white woman of thirty-eight, a native of Ireland, who complained of severe pain in both lower extremities, marked constipation, and polyuria of about ten weeks' duration. There were severe pains in the right leg, followed by numbness and progressive weakness in both legs. Roentgenograms of the spine, spinal fluid examination and echinococcus complement-fixation tests were not made. The patient was acutely ill, with distention of the abdomen, and bilateral flaccid paralysis of the lower extremities; there was loss of thermal, tactile, and pressure sensation of both lower extremities and trunk below the twelfth dorsal segment. Patellar, Achilles, and abdominal reflexes were absent. Two days after admission patient was unable to urinate or defecate voluntarily, became very toxic, and died eleven days after admission. The autopsy findings showed compression myelitis of the lower dorsal and upper lumbar cord; echinococcic pachymeningitis externa of the cord; multiple echinococcus cysts of the eleventh and twelfth dorsal and first lumbar vertebrae; a large, sterile, echinococcus cyst of the right kidney; the bodies of the eleventh and twelfth dorsal and first lumbar vertebrae were so friable that they could be broken easily. This was due to marked sponginess or cystic changes in the bone. Occasional scolices and numerous hooklets were found.

METHOD OF FORMATION OF DAUGHTER CYSTS

According to Loucks[8]:

"Daughter cysts found within the mother cyst, or which have originated by budding into the cavity of the mother cyst, are known as endogenous cysts. This term is used in contradistinction to the type of secondary cyst described as produced by external or exogenous budding. Daughter cysts formed by this method have been supposed to originate from 'foci of granular cells' situated in the cuticle from small islets of germinal epithelium left behind as 'inclusions' in the external laminated membrane or from 'aberrant cell nests' derived from the parenchymatous layer, and by process of exfoliation to escape gradually to the exterior where they continue to develop as separate cysts. This type of growth is comparatively rare, and in man is seen most frequently in cysts of bone, in recurrent cysts found in scar tissue, in cysts of the omentum, and occasionally in cysts of muscle and subcutaneous tissue."

Trauma has been given an important rôle in predisposing to infection, but Loucks and Dew feel that while it may call attention to an already

existing lesion, it has little effect upon the incidence of the disease. Walker and Cummins[9] in analyzing a larger series of bone hydatid cysts have shown that the pelvic girdle is the most frequent site of invasion (fifty-one per cent.). Next in order come the long bones—femur, humerus, tibia, etc.—although cases have been reported involving practically every part of the skeleton. The question as to the probability of direct invasion from the pelvic peritoneum is raised by the frequency of involvement of the bones of the pelvic girdle. However, coexistent visceral and bone involvement is rare. The epiphyseal ends of the long bones seem to afford a site of predilection for the parasite, and it is now generally accepted that it is lodged in the bone by way of the blood stream.

CLINICAL MANIFESTATIONS

This development within bone is essentially slow and free from symptoms, and appears to exhibit its greatest latency in osseous tissue. Pain, a late phenomenon, usually follows some complication,—such as infection or fracture. Loucks wonders that a high percentage of metastatic lesions has not been described for bone hydatid cysts, and in particular for those cases in which there has been a fracture, so that an opportunity has been afforded for the circulation of the viable elements of the organism by way of the ruptured vessels. In this connection, Dew considers Corlette's case[15] was of this type and likens the process to the occurrence of fat embolism following bone injury. Dévé's case[16] developed secondary pulmonary cysts following pathological fracture of the ilium.

DIAGNOSIS

Despite the rarity of this condition in North America, the possibility of its occurrence should be borne in mind as a cause of bone pathology.

Loucks states that in the early stages roentgenograms must be depended upon to suggest the diagnosis, but he admits the difficulties attendant upon correct roentgenographic interpretation, since no one surgeon is apt to see enough cases to draw upon his experience in diagnosis and since very little aid is at hand from other sources. For example, Anderson[17], in an excellent article dealing with the radiological diagnosis of hydatid infections, dismisses the subject of bone lesions in a single sentence.

On the other hand, Dew includes a complete discussion of bone infestations in his monograph on hydatid disease and states that "any bony lesion in an adult which exhibits extremely slow growth, is painless, shows lack of expansion of the cortex and remarkable absence of periosteal reaction in proportion to the degree of destruction present, should be strongly suspected of being caused by the echinococcus parasite".

Leborgne[18] presents an excellent clinical and roentgenographic description of osseous hydatid. From the clinical standpoint he mentions the pains, which are of varying intensity and which at times are entirely absent; and the rounded, indurated swelling, situated in the epiphysis at

the extremity of the bone, unassociated with increased surface temperature, requiring many months, even years, for development and sometimes ending in spontaneous fracture. Quoting Leborgne:

"Roentgenographic examination in the early period of the disease reveals one or many small cystic areas, like bunches of grapes, rounded, punched out, sharply outlined, but without the reaction of condensing osteitis at the periphery,—that is to say, without new bone formation. At a later period when the bony enlargement is perceptible on palpation, alteration in the contour of the bone is observed. This is in the nature of a fusiform expansion without new bone formation of any sort. The bone is seen to be reduced to a shell under the periosteum which may be broken through spontaneously. The bony swelling has a typical, areolar appearance, infiltrated by large cavities of more or less irregular contour, but discrete. From the anatomical point of view it corresponds to the process known as cystic osteitis.

"The absence of bone hyperplasia enables us to classify the x-ray appearance among the rarifying osteopathies and to rule out completely osteomyelitis, even of the attentuated form, which is sometimes associated with cystic cavities (Brodie's abscess). Bone syphilis or gummatous conditions, which produce cavities of rarifying osteitis, are encircled by a limiting ring of new bone formation.

"Among the rarifying osteopathies from which osseous hydatid must be differentiated are certain central osteosarcomata, round-cell or spindle-cell; but they must be distinguished by the different clinical setting, in the absence of sharp outline which permits us to separate hydatid disease of the bone.

"Among the other bone diseases which closely resemble hydatid disease of bone Recklinghausen's disease must be considered. The chief radiological difference lies in the contour of the rarifying areas, which are more clearly cut in hydatid disease. Although in Recklinghausen's disease the cavities correspond to pseudocystic nodules without true walls, or a process of osteoclasis infiltrates the periphery as in a malignant tumor, in hydatid infiltration of bone a true cyst with clear-cut walls is seen. In these cases clinical and general examination of the skeleton will be of great assistance in arriving at a diagnosis, since Recklinghausen's disease involves many bones. On the other hand, in solitary bone cysts the difficulties in diagnosis are much greater, because of the similar x-ray picture and the fact that there is but a single lesion. In such an instance the Casoni test will be helpful."

Leborgne concludes his description with a report of a case of a girl of nine, in which the humerus was involved.

It should again be noted that in the two Memorial Hospital cases herein reported the diagnosis was not made from clinical or x-ray study. It remained for the pathologist to determine the true nature of the condition, in the first case as a result of operative material submitted and, in the second, at autopsy.

Once a diagnosis has been suspected or even suggested, complement-fixation reaction or a Casoni intradermal test may be of value. Loucks states that in general the Casoni test is of most value in the diagnosis of early and uncomplicated cysts; it is of little significance in old, complicated cases. For a further discussion of the various tests for echinococcus disease, the reader is referred to Loucks' monograph.

HYDATID DISEASE OF THE INNOMINATE BONE

While the disease may occur in any of the flat bones, Dew[1] states that it is seen in its most usual and typical form in the innominate bones. Buzzi[19], Corlette[15], Syme[20], Landivar[21], Rendle[22], Bell[23], and others have reported cases. According to Dew, the latency of hydatid disease of the ilium is remarkable, the patient usually presenting a large swelling due to extension into the soft tissues from this comparatively thin bone. The thickness and tension of the gluteal muscles tends to cause this extension to develop in the iliac fossa, the pelvis, or the outer part of the thigh and a gradually increasing painless swelling develops in one of these areas. The swelling is fluctuant, indurated, relatively fixed, and is not tender to palpation. It is readily confused with other swellings in this region. Among these may be mentioned cold abscess, sarcoma, or chondroma with cystic degeneration.

EXPERIMENTAL PRODUCTION OF HYDATID DISEASE OF THE BONE

Dévé and Rolland[24] performed some interesting experiments in dealing with the production of bone echinococcus disease in a rabbit. Material was inoculated into the interior of the diaphysis of the tibia through a trephine opening about two centimeters from the joint. The animal died two years and three months later. Roentgenogram of the tibia, which had been inoculated, revealed the presence of multiple small cystic areas, rounded, confluent, and appearing to extend into the interior of the diaphysis up to five centimeters from the point of inoculation. Microscopic sections of the bone made throughout its entire length revealed that the parasitic invasion had extended down to the lower epiphysis. In two years the parasite had traversed the bone for a distance of more than ten centimeters. The daughter cysts were fertile and bore numerous capsules enclosing adult scolices. The bone cortex in the neighborhood of the parasitic infection did not present any thickening of a reactionary nature or any lesion of hypertrophic osteitis.

Dévé and Rolland[24] have thus verified in the case of a laboratory animal the various anatomical, pathological, and pathogenic features of uncomplicated osseous hydatid which one of them described[16] a decade previously.

ROENTGENOGRAPHIC FINDINGS

Little of value has been written on the roentgenographic diagnosis of hydatid disease of the bone. Harris[25], in 1919, stated that the disease

is always difficult to diagnose roentgenographically, as the appearance is so similar to that of an osteomyelitis. Others have noted its similarity to fibrocystic disease.

Hsieh[2] gives an excellent description of the roentgenographic features of his case of hydatid disease of the pelvic bone. That it can closely simulate a variety of bone conditions is readily understandable in view of the bizarre roentgenographic changes it may produce. Seldom has the roentgenographic diagnosis been correct; Kienböck and Mayer's recent case[26] is an exception, though lacking pathological or serological confirmation.

It is quite likely that in the future, as more attention is paid to the roentgenographic aspect of bone echinococcus and radiologists become more familiar with its features, the correct diagnosis will more frequently be made.

TREATMENT AND PROGNOSIS

The treatment of osseous hydatid is a discouraging chapter. It has usually consisted of wide excision or incision with curettage and the use of a cauterizing agent, such as carbolic or formalin. This method is condemned by Dew as "always unsatisfactory and, even if carried out thoroughly, when the disease is limited, it is unlikely to succeed".

Dew advocates complete resection of the length of bone involved, followed by immediate reconstruction with an autogenous graft. If there has been widespread destruction of either the soft tissue or bone, or if secondary infection has occurred, amputation is necessary. When the pelvic girdle is extensively involved, as in the cases we have described, treatment is most discouraging. Loucks expresses the view that "the only hope seems to lie in the discovery of some anthelmintic drug which, when administered by the intravenous route, will have a specific lethal effect upon the echinococcus organism".

Because of the fact that the organism develops in such a slow and symptomless manner, a pathological fracture is frequently the first manifestation that calls the patient's attention to the lesion. Pain is a late phenomenon and is generally attendant upon some complication, such as infection, pathological fracture, or perforation of the cortex. The delay in the recognition of the disease is one of the chief reasons why the prognosis is ultimately so discouraging. Dévé, Billiard, and Decoularé-Delafontaine[27], after experiments on infested animals, consider that deep radiation therapy has no effect on the cysts. The ideal therapy—complete extirpation—while adapted to certain visceral cases, affords extreme difficulty in a case of bone cyst. Amputation may give an excellent prognosis in cases where it is rendered necessary because of the extent of bone destruction.

So far as we have been able to determine, the two cases which we have described are the first in this country to have been treated by radiation, although it was given in each case before a correct diagnosis had been

made. In the first case the patient, though still alive, can scarcely be said to have benefited from the irradiation therapy and, in the second case, it is certain that this form of treatment was not followed by any relief.

CONCLUSIONS

1. Skeletal involvement occurs in less than one per cent. of cases of hydatid disease.

2. A roentgenographic diagnosis of osseous hydatid disease is extremely difficult.

3. But three cases of osseous hydatid have been reported in this country up to 1930.

4. Two additional cases (in both of which the bones of the pelvic girdle were involved) are reported from the Bone Tumor Department of the Memorial Hospital.

5. Intensive radiation therapy failed to check the disease or to alleviate the symptoms in our cases.

6. Hydatid disease should be considered among the causes of unusual bone tumors, from several types of which it is not always easily distinguishable.

BIBLIOGRAPHY

1. Dew, H. R.: Hydatid Disease: Its Pathology, Clinical Aspects, Diagnosis and Treatment. Sydney, The Australasian Medical Pub. Co., Ltd., 1928.
2. Hsieh, C. K.: Echinococcus Involvement of the Bones, with X-Ray Examination. Report of a Case. Radiology, XIV, 562, June, 1930.
3. Thomas, J. D.: Hydatid Disease. London, Baillière, Tindall and Cox. II, 125, 1894.
4. Vinas, M.: Quiste Hidatico de los Huesos Largos. Actas y Trabajos del Segundo Congreso Nacional de Medicine, Buenos Aires, I, 504, 1923.
5. Mills, H. W.: The Surgical Treatment of Echinococcosis. Med. J. and Record, CXXII, 460, 1925.
6. Dévé, F.: L'Echinococcose de l'Enfant. Arch. d. Méd. d. Enfants., XXI, 225, 1918.
7. Vegas, H., et Cranwell, D. J.: Les Kystes Hydatiques et Leur Traitement dans la République Argentina. Rev. de Chir., XXIII, 470, 1901
8. Loucks, H. H.: Hydatid Cyst; A Review and a Report of Cases from North China. Nat'l Med. J. of China, XVI, 402, Aug. 1930.
9. Walker, C. A., and Cummins, W. T.: Echinococcic Bone Disease, Report of a Case. J. Am. Med. Assn., LXVIII, 839, 1917.
10. Lyon, I. P.: A Review of Echinococcus Disease in North America. Am. J. Med. Sciences, CXXIII, 124, 1902.
11. Hines, L. E.: Compression Myelitis Secondary to Echinococcus Disease of Vertebrae and Kidney. Arch. Path. and Lab. Med., I, 180, 1926.
12. Osler, William: On Echinococcus Disease in America. Am. J. Med. Sciences, LXXXIV, 475, 1882.
13. Sommer, H. O.: Echinococcus Disease in the United States. New York Med. J., LXII, 656, 1895; LXIV, 263, 1896.
14. Woods, G. W.: Echinococcus-Hominis.—A Remarkable Case of Echinococcus, Manifested First in the Chest Wall and Subsequently in Osseous Tissue of Left Humerus. Proc. Assn. Military Surgeons, VIII, 157, 1899.
15. Corlette, C. E.: Hydatid Infestation of Bone, Multilocular Hydatid Disease and Ordinary Hydatid Cysts. Med. J. Australia, I, 73, 1920.

16. Dévé, F.: L'Échinococcose Viscérale Métastatique chez l'Homme. Compt. Rend. Soc. de Biol., LXXIX, 697, 1916.
17. Anderson, C. C.: The Radiological Diagnosis of Hydatid Infection. British J. Radiol., I, 428, 1928.
18. Leborgne: Les Kystes Hydatiques des Os. Bull. et Mém. Soc. de Radiol. Méd. de France, XV, 33, 1927.
19. Buzzi, A.: Sabre un Caso de Quiste Hidatico del Hueso Coxal. Rev. Assoc. Med. Argentina, XXXV, 756, 1922.
20. Syme, Sir George: Surgical Aspects of Hydatid Disease. Med. J. Australia, Supplement, 393, 1927.
21. Landivar, A. F.: Quiste Hidatico Multilocular del Hueso Coxal Derecho. Actas y Trabajos del Segundo Congreso Nacional de Medicine, Buenos Aires. I, 526, 1923.
22. Rendle, C. E. R.: Note on a Case of Primary Hydatid of Bone. Lancet, I, 1162, 1913.
23. Bell, G.: Hydatid Disease of the Innominate Bone. Med. J. Australia, II, 361, 1926.
24. Dévé, F., et Rolland, P.: Échinococcose Expérimentale du Tibia. Étude Histologique. Compt. Rend. Soc. de Biol., XCVII, 1132, 1927.
25. Harris, H.: Hydatid Disease of Bone. Am. J. Roentgenol., VI, 277, 1919.
26. Kienböck, R., und Mayer, E. G.: Ein Fall von Echinokokkose des Beckenknochens. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXIX, 1026, 1929. Abstracted in Zentralbl. f. d. Ges. Radiol., VII, 548, 1930.
27. Dévé, F., Billiard, A., et Decoularé-Delafontaine, A.: Sable Hydatique et Radiothérapie Pénétrante. Compt. Rend. Soc. de Biol., XCI, 851, 1924.

THE TREATMENT OF FRACTURES OF THE SHAFTS OF THE TIBIA AND FIBULA

A New Tibia Traction Apparatus*

BY R. WATSON JONES, F.R.C.S.ENG., M.CH.ORTH., LIVERPOOL, ENGLAND

INTRODUCTION

The history of fracture treatment can be traced back through countless generations. Even so, the last half century has witnessed remarkable and dramatic advances in this branch of surgery. In the past, it was regarded as inevitable that the victim of a fracture should carry to the grave some mark of his injury, whether it be a shortened limb, a stiffened joint, a crippling deformity, or a halting gait. Gradually, as methods improved, the seriousness of the residual incapacity diminished; but unfortunately this medieval view has not entirely disappeared, and it is still customary to regard certain permanent disabilities with equanimity. There are surgeons who are content with shortening of a limb provided that the shortening is not more than one inch, who discount angulation of the tibia so long as the angulation is outward and not inward, and who entirely disregard certain degrees of limitation of ankle movement, leaving to the unqualified bone-setter the opportunity of completing their work.

The only standard of treatment, which can be allowed to survive, is that of a limb indistinguishable from normal. Such a result implies not only that the fragments are united in perfect alignment, with no local thickening and with no shortening, but that the bones are fully recalcified, the muscles completely redeveloped, joint movements normal, and the circulation fully reestablished so that there is no recurring oedema. The surgeon cannot shelve his responsibility by invoking the magical powers of a masseuse, but must accept full liability for the disuse changes which he allows to appear. From the first day of treatment, his objective must be a limb so fully recovered that the patient himself remembers only with difficulty which leg was fractured.

If a fracture can be treated either in recumbency or by ambulation, it must be obvious that ambulatory methods will be the more successful. Provided that fixation of the fragments is perfect and no recurrence of deformity is possible, no harm can arise if weight is borne through the limb. On the contrary, weight-bearing will prevent disuse changes from appearing, the indications for massage and physiotherapy will never arise, the incapacity period will be correspondingly reduced, consolidation of the fracture will be secured with much greater certainty, the risk of functional complications will be avoided, and the inconvenience to the patient minimized.

* Based on a paper, film, and demonstration, presented at the Annual Meeting of the British Orthopaedic Association, Newcastle-on-Tyne, October 1931.

FRACTURES WITHOUT OVERRIDING

From the point of view of treatment, fractures of the shafts of the tibia and fibula may be divided into two groups, differentiated by the presence or absence of overriding. Crack fractures, greenstick injuries, and fractures with angulation but no overriding present little or no difficulty in treatment. Perfect reduction can be secured by simple manipulation, and it is easy to maintain reduction by the application of a plaster cast, applied with the limb hanging over the end of a table in the line of gravity. If the plaster is closely fitting and unpadded, weight-bearing may be commenced at once, and the fractures should be firmly united in six to eight weeks.

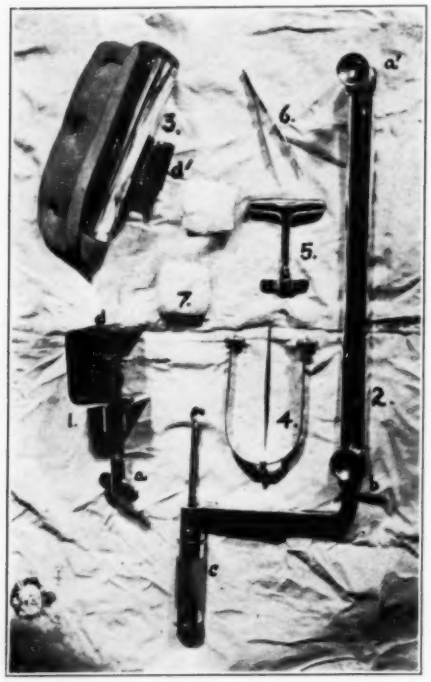

FIG. 1

Tibia Traction Apparatus. *1*. Clamp to fit any table top. *2*. L-shaped traction bar. *3*. Thigh support, padded with sorbo rubber. *4*. Os-calcis stirrup and pin (sterile). *5*. Bristow's pin introducer (sterile). *6*. Sterile forceps for handling pins. *7*. Two sterile gauze pads. After screwing the clamp on the table, the screw handle at *a* swivels into the axis of the screw to allow the top of the traction bar (*a'*) to slide over it and be locked into position. The base of the thigh support (*d'*) fits into a slot on the top of the clamp (*d*). The coarse adjustment of the traction bar is at *b* and the fine adjustment at *c*.

FRACTURES WITH OVERRIDING

It is the second group, including complete fractures with overriding due either to total disengagement of the fragments or to the obliquity of the fracture line, which presents the difficult problem, a problem rendered still more difficult when the fracture is compound and infected, and associated with extensive abrasions and lacerations of the overlying skin.

Disadvantages of Continuous Traction Methods

It has been customary to treat these fractures either by extension apparatus of various types, or by an open operation with internal fixation. Both routines are associated with very real disadvantages and difficulties. Extension methods can only be successfully applied if the services of expert splint-makers and fully trained nurses can be commanded. They demand constant supervision and frequent adjustment, and the advantages of ambulatory treatment are lost. Frequently skin extension is impossible because the skin is so extensively injured. Continuous skeletal traction by means of an os-calcis

pin is not devoid of the risk of infection extending along the pin track, and if strong traction is maintained on the os calcis behind the ankle joint for any length of time, the tendo achillis may become overstretched and an intractable talipes calcaneocavus arise.

FIG. 2

Showing the limb in traction ready for the application of plaster. The traction apparatus has been assembled and clamped on to the table. The os-calcis pin has been introduced. About two-thirds of the fine adjustment screw has been taken up into the handle.

Disadvantages of Open Operation

The success of operative reduction is still more dependent on the skill of the surgeon. But, even assuming that asepsis can be relied on with absolute confidence, the stripping up of soft parts from the bone ends causes definite delay in union.

Difficulties of Treatment by Manipulation and Plaster

It follows that if equally perfect reduction can be secured by manipulation and plaster, this routine is preferable to either extension or operative methods. If it is proposed to attempt this by the ordinary procedure of holding the limb vertically over the end of a table, an assistant must be found, who, with a very insecure grip on the patient's heel can maintain considerable traction for ten or twenty minutes, and at the same time allow neither lateral nor anteroposterior angulation to appear, hold the foot in the same plane of rotation as the patella, dorsiflex the ankle to a right angle, and keep his hands out of the way of the plasterer. Formidable as the task may appear, it is possible in recent injuries, with a well trained assistant. But assistants are not always available; they are subject to fatigue; and fractures are not always seen within a day or two of the injury.

TIBIA TRACTION APPARATUS

For these reasons, a piece of apparatus has been designed which is in fact a mechanical assistant of a very perfect order, indefatigable, and capable of fulfilling all of the demands imposed by a complete fracture of both leg bones. These demands may be enumerated as follows:

1. The knee must be flexed to a right angle.
2. The limb must be held vertically in the line of gravity.
3. Heavy traction must be maintained long enough for the application of plaster.
4. No traction pin should be left in the bone.
5. The foot must be in the same plane of rotation as the patella.

6. Lateral and anteroposterior angulation must be fully corrected.
7. The apparatus should be easily portable and applicable anywhere.
8. The apparatus must be adjustable to any size of limb.
9. The operator should be independent of assistants.

The apparatus is simple in construction and design (Fig. 1) and consists of a clamp to fit any table, an L-shaped traction bar with coarse and fine adjustments, and a padded thigh support. It can easily be carried in an attaché case and is roughly the size and weight of a Thomas wrench. Traction is applied to the limb by means of an os-calcis stirrup and pin, but the pin is withdrawn as soon as the plaster is dry so that there is no risk of infection along the track, or of overstretching the Achilles tendon.

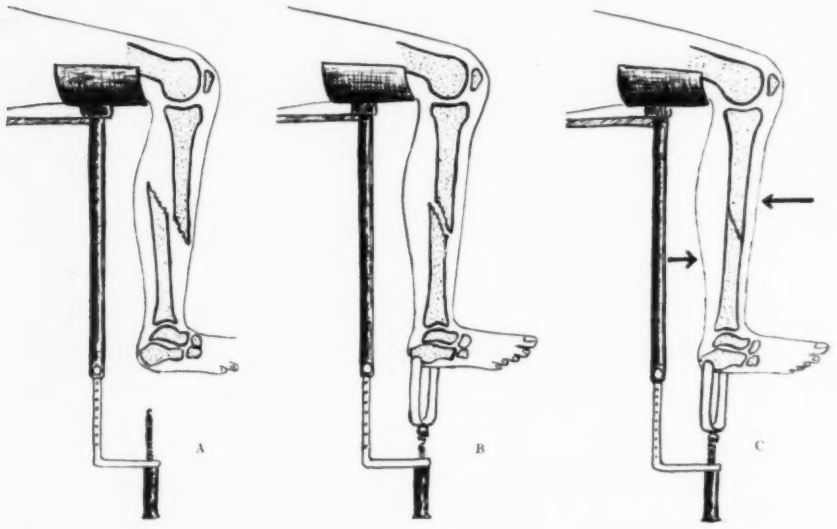

FIG. 3

Anatomical reduction is secured by combining the lateral pressure of the operator's hands with the strong traction of the apparatus.
A. Before reduction.
B. After applying traction.
C. Lateral pressure and traction combined.

APPLICATION OF THE METHOD IN CLOSED FRACTURES

Introduction of Pin

The skin of the foot and leg is thoroughly prepared with ether and iodin. The os-calcis pin is introduced with full aseptic precautions and should be driven through the posterior superior angle of the os calcis, strictly at right angles to the sagittal plane of the limb. Any obliquity in its axis may make it difficult to keep the foot and patella in the same plane of rotation.

Use of Apparatus

The traction bar and thigh support are clamped on to any convenient table; the fractured leg is flexed at the knee joint to a right angle, and

FIG. 4

First stage of the plaster completed. While waiting for the plaster to harden thoroughly, a window is cut over the front of the ankle at the point where recoil of the limb after release of the traction will exert greatest pressure.

FIG. 5

The complete plaster. The pin has been withdrawn, heel of the plaster repaired, and the plaster extended to the level of the upper thigh.

hangs vertically over the end of the table with the lower thigh resting on the padded support and the heel vertically above the hook of the traction bar. The os-calcis stirrup, fixed in position on the pin, is hooked to the traction bar (Fig. 2). By means of the coarse adjustment the limb is lengthened as much as possible, and the traction bar is fixed at this length. A further three inches of lengthening can be gradually secured by easy rotary movements of the fine adjustment handle. Traction is gradually increased until the limb is quite taut and the operator feels the crepitus of the fragments which are now in apposition. As a rule, full length has been secured by the time that two-thirds of the fine adjustment screw has been taken up. There need be no fear of applying too great an extension; the length of the traction screw has been so adjusted as to make it impossible to do harm by overextension, and slight overlengthening can easily be corrected at a later stage (see *Wedging of Plaster*).

The overriding is now fully corrected, and the traction is such that no angulation can remain; the foot is automatically dorsiflexed to a right angle and if the axis of the pin is correct there can be no rotation displacement. The fragments may now be firmly locked against each other by lateral pressure between the operator's hands. The limb is held so rigidly by the traction that lateral pressure of this type cannot produce angulation, but can only impact the fragments in such a way that anatomical reduction is secured. This lateral pressure should be constantly maintained by the operator until the plaster is dry. *The apparatus itself will maintain full length and correct alignment, and the lateral pressure of the operator's hands will secure perfect apposition* (Fig. 3).

FIG. 6-A

Complete fracture of the shafts of both leg bones. (This fracture could easily have been reduced perfectly without the traction apparatus, but it was the only case available when the film was being prepared. It is reproduced here because it illustrates a complication.)

FIG. 6-B

After reduction (through plaster). The limb has been overlengthened and the plaster fits so closely that the separation of the fragments will be maintained unless the traction is released by a circumferential cut in the plaster (see text).

Application of Plaster

An unpadded plaster cast is applied from the toes to the level of the knee joint. A plaster slab, prepared quickly so that it is still quite moist and soft, is guided through the stirrup, placed in direct contact with the skin of the back of the leg and sole of the foot, and molded to the limb by means of a thin cotton bandage lightly applied. The cast is now completed in the ordinary way with circular turns of plaster bandage.

FIG. 6-C

The end result. The overlengthening has been corrected and union has resulted.

Window in Front of Ankle

The traction must be maintained until the plaster is quite hard. While waiting for it to dry, it is a wise precaution to cut a small vertical window one inch wide over the front of the ankle joint (Fig. 4). In one of the earliest cases in which the apparatus was used by one of my assistants, a pressure sore developed at this point, probably due, not to a badly applied turn of plaster, but to recoil of the limb within the plaster after release of the traction. In order to obviate this with certainty, we have always cut a small window at the point where recoil will cause greatest pressure.

The traction is now released, the knee straightened to twenty degrees short of full extension, and the plaster continued to the upper thigh. The pin is withdrawn from the os calcis after resterilizing the projecting part with iodin, and the plaster is completed over the heel (Fig. 5).

COMPLICATIONS

Impairment of Circulation

Over 100 cases of fracture of both leg bones have been reduced with this traction apparatus by the author and many assistants and colleagues (Figs. 6-A to 10-B). With the single exception of the early case referred to, no complication has ever arisen. The circulation in the toes is always carefully observed, but it has not yet been found necessary to cut down the plaster. While the plaster is actually being applied and the limb is

in heavy traction, it is obvious that the popliteal artery will be temporarily obliterated and there will be no circulation in the foot. This is restored, however, as soon as the traction is released, and before the plaster is continued to the upper thigh. We have seen no ill effects from pressure against the thigh support.

First Aid Measures

Fractures are reduced and put up in plaster at once, at whatever stage they may be when first seen. If for reasons of personal convenience a case cannot be immediately reduced, the fracture hematoma is injected with fifteen cubic centimeters of two per cent. novocain in order to relieve pain and shock, and a firm flannel bandage is applied from the toes to the knee in order to prevent swelling from appearing. If swelling is allowed to appear, it will not only be difficult to feel the fragments when reduction is attempted, but the plaster will become very slack in two or three weeks and may allow angulation to reappear.

Is Swelling a Contra-Indication?

The fear of swelling has, in the past, dominated treatment to an unreasonable extent. The only swelling which need cause real anxiety is that due to bleeding from a torn tibial artery, and in this case the tibial pulse is already weak or obliterated, the foot cold and blue, and the diagnosis obvious. In all other cases the swelling is simply due to mild hemorrhage from the fractured surfaces with traumatic oedema, and both factors are entirely within the control of firm external support. A plaster applied before the onset of swelling will prevent it from appearing, and there is very little likelihood of the pressure within the plaster being raised to the point of impairment of circulation. Care in observing the color of the toes is all that is necessary to avoid a catastrophe. If it is safe to apply plaster before the limb is swollen, it is obviously still more safe to apply it after swelling has appeared, and lack of thought is the only excuse for the claim so often made that a limb "was too swollen to do anything".

Is Blistering a Contra-Indication?

The old objection that blistering may appear twenty-four hours later and pass unrecognized if the limb is already encased in plaster, is still more fallacious. Skin blistering in the region of a fracture is due to oedema of the cuticle, and appears only when there is no external support, or when the external support is unequal. If two lateral splints have been applied to a leg, blisters will develop in front and behind, between the splints, but not beneath them. If the external pressure is quite uniform and regular, as is the case with a properly applied plaster, blisters never appear. If the fracture is of more than twenty-four hours' duration and blisters have already developed, they should be evacuated, dusted over with talc, and the plaster applied as before. Unless secondarily infected, they are always aseptic and will be quite healed when the plaster is

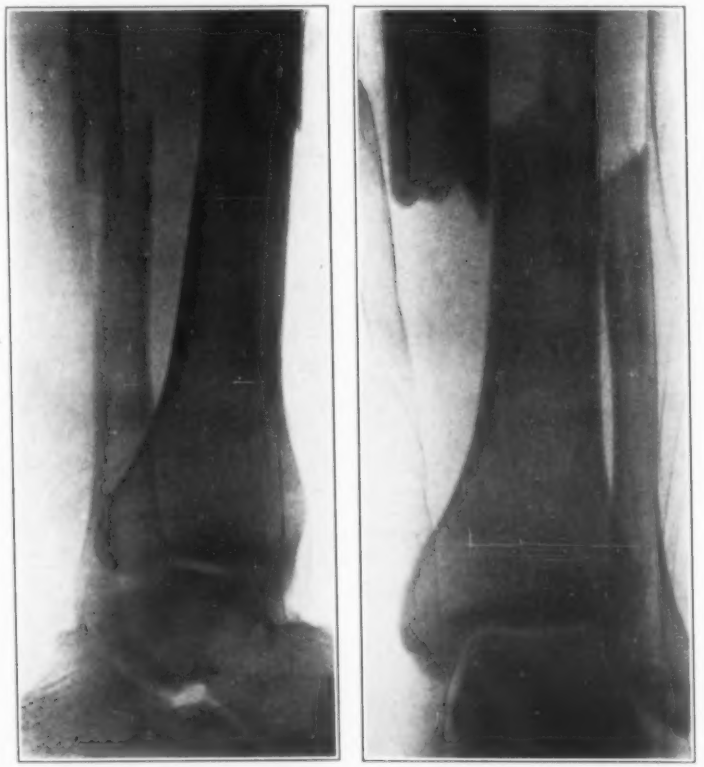

FIG. 7-A

Transverse fracture of both leg bones with overriding.

FIG. 7-B

After reduction (through plaster). After perfect apposition had been secured with heavy traction, the fragments were allowed to impact by slightly reducing the traction before applying plaster. It is unwise to do this in spiral or oblique fractures.

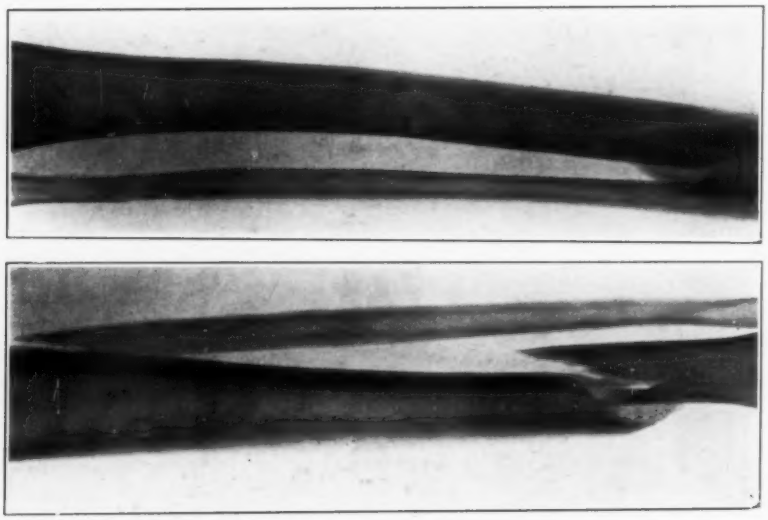

Fig. 8-A
Spiral fracture of both leg bones with overriding.

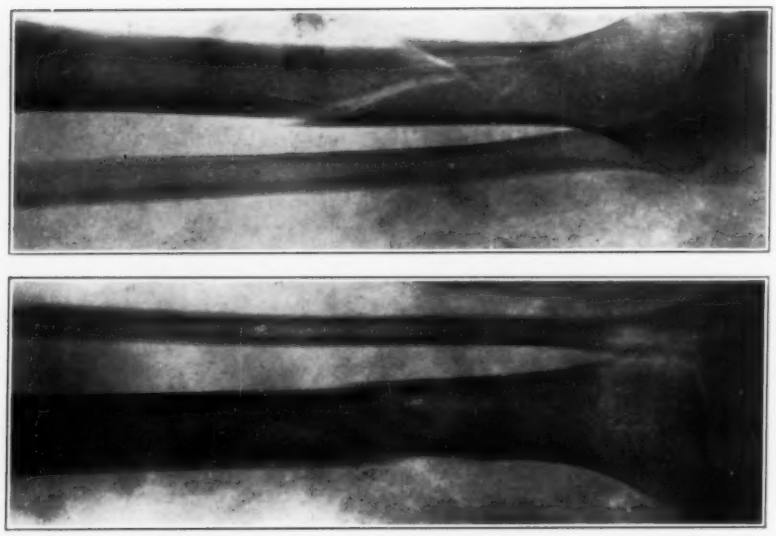

Fig. 8-B
Spiral fracture after reduction (through plaster).

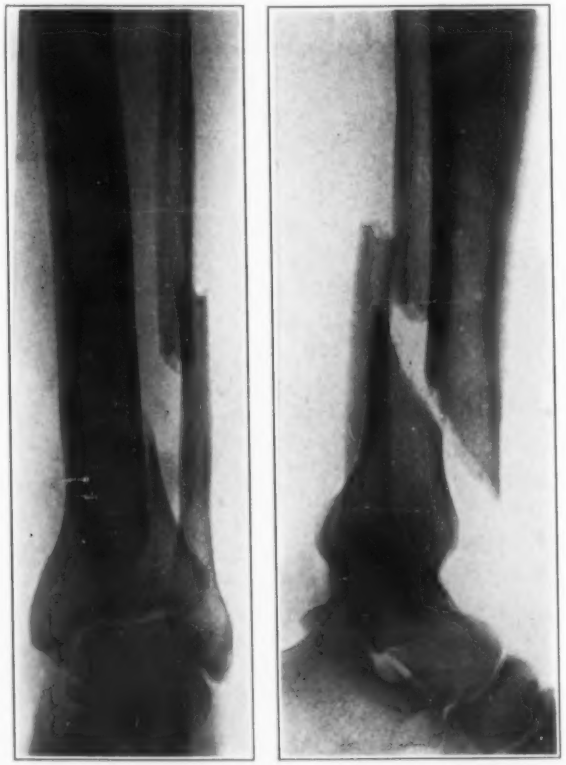

FIG. 9-A

Low oblique fracture of both leg bones with overriding. Without the tibia traction apparatus this is a very difficult fracture to treat conservatively, because the fragments re-displace as soon as the foot is dorsiflexed at the ankle joint.

FIG. 9-B

Oblique fracture after reduction (through plaster). The slight inward and backward angulation was corrected by wedging the plaster (see text).

FIG. 10-A

Six-months-old compound fracture of both leg bones. The distal and middle fragments were plated together, skeletal traction maintained for fourteen days, and the limb then put up in plaster, and the plate removed through a window.

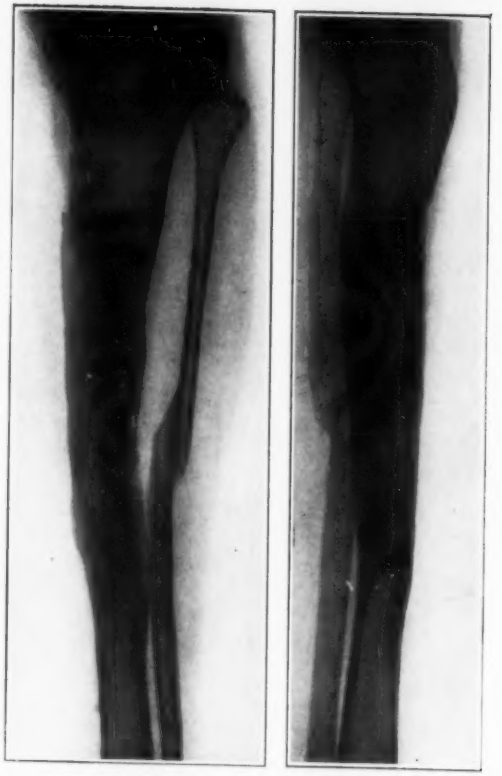

FIG. 10-B

The end result of a six-months-old compound, malunited fracture.

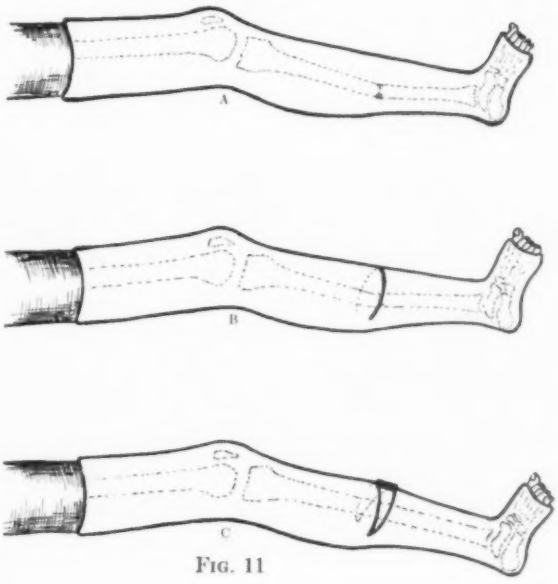

FIG. 11

A method of wedging plasters, allowing correction of slight angulation with perfect control. A linear cut around two-thirds of the circumference of the plaster on the concave side of the angulation (*B*) is opened to a wedge (*C*). A block of wood is inserted and a roentgenogram taken. Undercorrection or overcorrection is controlled by increasing or decreasing the size of the block of wood. The block is moved nearer to the side or nearer to the front, according to whether the remaining angulation is mainly lateral or mainly anteroposterior. When the roentgenogram shows perfect alignment, the plaster is repaired and the block of wood incorporated.

removed. However extensive and severe blisters may be, no windows should be cut, because the lack of support will cause further oedema and blistering, and repeated dressings can only cause infection.

X-RAY CONTROL OF REDUCTION AND WEDGING OF PLASTERS

Immediate X-ray

It is, of course, of primary importance that the success of reduction should be confirmed at once by anteroposterior and lateral roentgenograms taken through the plaster. The films must include the whole length of the bones in order to detect the slightest degree of angulation.

Wedging of Plaster

If the technique has been faulty and any angulation remains, this should be corrected by wedging the plaster, however trivial the degree of deformity may appear. It is not advisable to cut out a wedge of plaster and close the gap together, because this involves some risk of a pressure sore. A linear cut should be made around two-thirds of the circumference of the plaster at the level of the fracture on the *concave* side of the angle. The linear division is opened to a wedge, and a small block of wood, one-third of an inch thick and one inch wide, is placed between the two cut edges (Fig. 11). The depth of the block of wood will vary according to the correction required. A very short gas anaesthetic may be used for the actual manipulation. The block of wood must be exactly opposite the angle—in front of the leg for backward angulation, on the inner side for outward angulation, half-way between the two for both backward and outward angulation, and so on. Before the plaster is repaired another roentgenogram is taken, and if necessary the degree of correction increased

or decreased by inserting larger or smaller blocks. When the alignment is quite perfect, the gap in the plaster is filled and reenforced.

Correction of Overlengthening

If the x-ray shows that, although alignment and apposition are perfect, the limb has been overlengthened by a quarter or a third of an inch, the plaster should be cut around the whole of its circumference in the middle third of the leg (not necessarily at the level of the fracture), the gap made by the plaster shears closed with direct vertical pressure, and the plaster repaired.

AFTER-TREATMENT

Ambulatory Treatment

Weight-bearing is a very necessary factor in prevention of disuse changes, and in the acceleration of consolidation. Provided that apposition is strictly end-to-end, that the fracture line is not too oblique, and that the plaster is still closely fitting, patients should walk freely, bearing weight on the limb from the second or third week. With very oblique fractures it is wise to defer weight-bearing until the sixth week. If the plaster is applied to a very swollen limb, in three weeks' time it will be too slack for weight-bearing to be safe. In this case, a new unpadded plaster is applied during the sixth week, and weight-bearing is then commenced.

FIG. 12

The patient may walk in three weeks. Normal dress is worn with a special plaster boot. Note the sorbo heel incorporated in the plaster, to avoid the jar of weight-bearing.

Advantages of a Rubber Heel in the Plaster

The incorporation of a sorbo rubber heel in the plaster avoids the jar of weight-bearing, and frequently patients who could not otherwise be persuaded to walk will do so with ease and comfort. The rubber adds a certain spring to the gait. The rubber should be applied outside the ordinary plaster and held in position beneath the heel with a few turns of plaster bandage. It must be emphasized that ambulatory treatment does not mean that the patient hobbles about on crutches carrying the injured limb. Although he may be allowed one crutch for a day or two, he must ultimately walk with no more assistance than that of a single stick (Fig. 12).

Plaster Boot

The incorporation of a metal stirrup such as that advised by Böhler is not advisable. Not only does the stirrup fail to relieve the jar of weight-bearing but it prevents the wearing of a boot, and no patient will walk about the streets of a city unless his dress is more or less

normal. For a few shillings a cloth boot can be made to cover the plaster, and the patient who cannot afford a special plaster boot can improvise one from a galoshe.

Treatment of Delayed Union

In eight weeks from the date of injury, the plaster is cut down and the degree of union estimated by a gentle clinical examination. If the fracture is firmly consolidated, no further immobilization is necessary. As a rule, however, it is advisable to reapply an unpadded plaster to just below the knee joint, and the patient continues to walk and to practise exercises for the recovery of knee movement. This plaster is removed and union tested at intervals, according to the degree of consolidation which had been found at the last examination. Most fractures are consolidated in ten weeks from the date of injury. In cases of delayed union, the fixation is continued as long as necessary up to four or five months. With such a routine it is practically never necessary to operate for non-union, even where the fracture has been infected. The practice of prescribing massage, percussion, damming and other physiotherapeutic measures is in our opinion definitely harmful. The essential factor in securing consolidation is constant, unremitting, and absolute fixation of the fragments on each other, while, at the same time, disuse changes are prevented by continued functional activity. Even occasional sheering or straining movements will still further delay union, and such is inevitable if the limb is daily lifted out of plaster to dam and hammer it. With such treatment, deformity is not infrequently allowed to appear, although in the earlier stages it was prevented with complete success.

Inefficiency of Ambulatory Splints

A short iron and T strap is never used as a convalescent brace. Either the fracture is so firmly consolidated that the iron is unnecessary, or it is not consolidated and, therefore, demands protection from *any* angulation, and not simply protection from inward angulation. Unlike the plaster cast below the knee, an outside iron and inside T strap do nothing to prevent backward angulation. Not only so, but cases may often be seen where bandaging an unsoundly consolidated fracture to an outside iron has actually produced outward angulation.

Inefficiency of Delbet Plaster

The Delbet plaster is equally unsound in principle and in practice. The fixation afforded by such a plaster is definitely inferior to that of a complete cast, and the inequality of external support fails to control oedema. The circular turns of plaster below the knee and above the ankle may even aggravate the tendency to oedema. Not only does such oedema delay recovery, but it stimulates adhesion formation around the ankle, and the slight ankle movement permitted by the Delbet plaster is

FIG. 13-A

Application of tibia traction apparatus to crush fractures of the os calcis. The pin is usually introduced above the os calcis just in front of the tendo achillis. Böhler's clamp reduces lateral spreading after the vertical crushing is corrected and while the limb is still in traction.

FIG. 13-B

Crush fracture of os calcis after reduction.

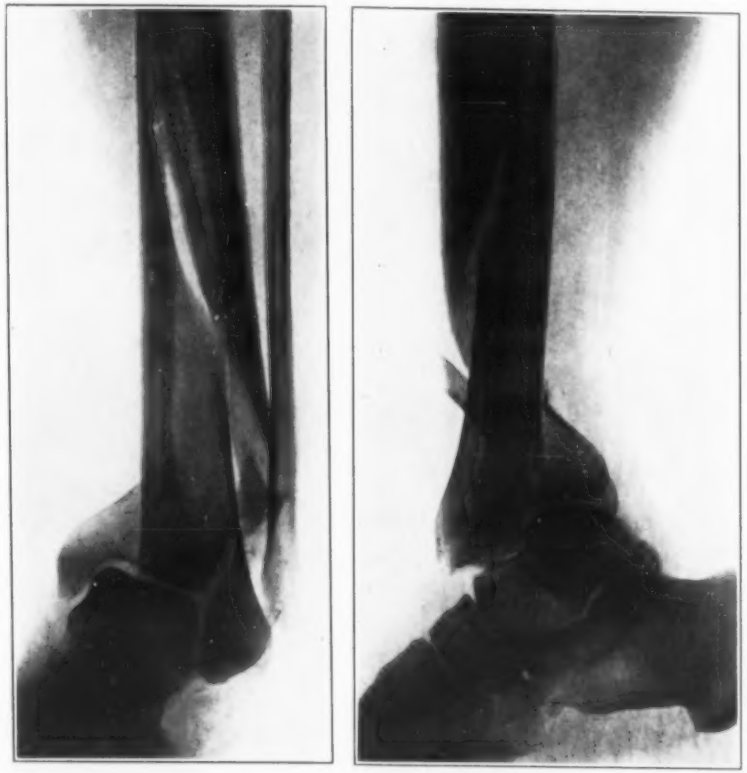

FIG. 14-A

Fracture-dislocation of ankle, with comminuted spiral fracture of tibia.

FIG. 14-B

Same case after reduction (through plaster).

FIG. 15

Application of tibia traction apparatus in bone-lengthening operations on tibia. In this case one inch of lengthening was required. This was secured by Abbott's method in ten days, and plaster was then applied with the limb in traction.

insufficient to prevent this. Finally, the development of muscle tone is just as efficiently maintained by constant walking in a complete cast as by constant walking in a Delbet cast.

Prevention of Recurring Oedema

It is important that recurrent oedema of the leg after removal of the plaster should be prevented. The oedema is due to leakage of fluid from the small vessels into the tissue spaces, and is a result of hypotonicity of the musculature of the limb, and particularly of the musculature of the arterioles. However frequently the fluid may be dispersed by massage, it will continue to recur until the muscle tone has fully recovered. Although in the healthy young adult control may be rapidly established, in other patients a persistent and even progressive complication arises. Every time that the serum is allowed to escape, the track is distended and made more patent. Not only so, but the weight and discomfort of the swollen oedematous limb may be so great that the exercise necessary for its control is impossible, and a vicious circle is established. Many months of disability result, and simple oedema of hypotonic musculature may be seen as long as two years after fracture.

Massage for twenty or thirty minutes daily, though capable of temporary dispersal of the fluid, is no substitute for the patient's exercise throughout his ten or fifteen waking hours, and as a rule physiotherapy does nothing more than to prevent progress of the disorder. The essential treatment is to prevent the oedema from ever appearing, while at the same time the patient develops his musculature by constant exercise. Ambulatory treatment has already gone far in this direction, and the wearing of a suitable support, firm enough to prevent swelling but not rigid enough to prevent movement, for six weeks after discarding the plaster will establish control. A crêpe bandage is unsuitable because it becomes loose and, if badly applied, may even aggravate the oedema by being too tightly applied around the upper calf. Böhler's zinc-gelatine-paste demands considerable time in preparation and application. Bandages already impregnated with Unna's paste, in the proprietary form known as the "Viscopaste" bandage, provide an ideal medium, which is always ready, requiring no preparation, and giving just sufficient support without immobilization. As soon as the plaster is cut off, a viscopaste bandage is applied, and is

retained until the patient recognizes that it is no tighter at the end of the day than it was at the beginning. No massage or physiotherapy is necessary and months of disability are avoided.

Treatment of Adhesions around the Ankle Joint

Throughout the time that the viscopaste bandage is retained, inversion and circumduction movements of the ankle are practised at regular intervals each day. If, after six weeks, there is still limitation of inversion and plantar-flexion, with pain when these movements are performed passively, it is evident that adhesions are still present. Unless these adhesions are fully stretched they may persist indefinitely, and for years afterwards the patient complains vaguely of "weakness of the leg", "a feeling of giving way", and "difficulty in going downstairs". It is surprising with what constancy qualified surgeons will ignore such complaints, or advise rest, or attribute the symptoms to arthritis of the ankle, or dismiss them as the inevitable penalty of fractures of the leg or ankle. Very frequently the patient drifts to a bone-setter, his disability is cured in ten days, and quite naturally he is much more grateful to the unqualified practitioner who completed his treatment than to the qualified surgeon who failed at the last stage only. If the patient has been unable to stretch the adhesions during six weeks of ankle exercise, they should be snapped by manipulation under a short anaesthetic. The important movements for the full stretching of residual adhesions are inversion of the heel, adduction of the forefoot, and plantar-flexion at the ankle and mid-tarsal joints.

APPLICATION OF THE METHOD TO COMPOUND FRACTURES

Within a Few Hours of Injury

If it is possible with safety to convert the compound into a closed fracture, this should be attempted. The method must not be attempted unless the case is seen within an hour or two of injury, and unless the primary débridement is complete. The skin is stitched and the fracture then reduced by means of the traction apparatus in the ordinary way. A window over the wound allows it to be exposed to the air, in order to give the maximum opportunity of drying and of healing by first intention.

Principles of Treatment of Definitely Infected Fractures

If the fracture is several days old and infection already established, or if primary excision and suture has failed, or if the operator doubts the efficiency of his primary excision, there can be little doubt that the no-dressing, Winnett Orr method offers the best chance of securing a limb indistinguishable from normal. Whether or not surgeons are prepared to agree as to the advisability of treating simple osteomyelitis by this method, it must be agreed that there is no other method which at the same time allows perfect fixation of the fracture with perfect control of the infection. One or the other element of the treatment usually receives preference and, as a rule, treatment is concentrated during the first month or two on the infection, while the position and the immobilization of the frag-

ments is regarded as of secondary importance. The view that infection is a cause of non-union is now well established. Actually, however, infection does nothing more than to delay union by the excessive decalcification of persistent hyperaemia. But, if during this time immobilization is interrupted or is imperfectly maintained, non-union results just as surely as it would result in a closed fracture which was imperfectly immobilized. The only difference is that in the closed fracture immobilization must be maintained for ten weeks, whereas in the infected fracture equally perfect immobilization must be maintained until the infection is quiescent and the wound healed, and for ten weeks longer. With this routine, the majority of infected fractures unite firmly by bone without the necessity of a bone-grafting operation.

Technique in Infected Fractures

The limb is fixed in the traction apparatus, the wound excised, necrotic and entirely loose fragments removed, and free drainage established. The saucerized wound is packed with vaselin gauze, the skin thoroughly protected with vaselin, and a padded plaster cast applied. The use of the traction apparatus makes it quite unnecessary to leave pins in the bone as recommended by Winnett Orr.

In four weeks a new plaster is applied and any sequestra which have separated are removed. Successive plasters are applied as necessary. When the granulated wound has epithelialized and is quite dry, an unpadded cast is applied and weight-bearing commenced, whatever degree of union may have developed. Successive roentgenograms show rapid refilling of cavities, and, after quiescence of infection, as weight-bearing is continued, rapid recalcification of the bones. The alignment and length of the limb having been maintained throughout, when consolidation is finally secured, it is unaccompanied by deformity or shortening.

CONCLUSION

A new tibia traction apparatus which is simple in construction, easily portable, and applicable anywhere under any circumstances, has been found in a large series of cases to be of the greatest value in treating overriding fractures of the shafts of the tibia and fibula. The surgeon experienced in its use may secure anatomical reduction without operative interference with almost unfailing constancy, and the most inexperienced amateur will find that the treatment of these otherwise difficult cases becomes greatly simplified.

The apparatus may also be used for the reduction of crush fractures of the os calcis (Figs. 13-A and 13-B), difficult Pott-Dupuytren fractures (Figs. 14-A and 14-B), and for the application of plaster after a bone-lengthening operation on the tibia (Fig. 15).

The development of the apparatus in its early stages and the general routine of treatment which has been described are the result of team-work, and the author would particularly record his indebtedness to the Orthopaedic Registrar at the Liverpool Royal Infirmary, Mr. W. Sayle Creer.

THE TREATMENT OF OSTEOMYELITIS IN THE WARM SALT-WATER POOL *

BY A. BROCKWAY, M.D., LOS ANGELES, CALIFORNIA

During the past few years there have been a number of new ideas advocated for the treatment of this very stubborn disease, and the writer would hesitate to present a still different outline of treatment, but for the fact that he is convinced that the method to be described here embodies certain definite principles in the treatment of infection and joint healing that makes it well worth bringing before the medical profession. While we have used the warm salt-water pool in all types of non-tuberculous osteomyelitis, it has its greatest field of usefulness in those cases where the involvement is in close proximity to the joint line or where the process involves the joint structure as well.

During the past four years, up until eight months ago, the Winnett Orr treatment has been used at the Orthopaedic Hospital with a great deal of satisfaction, a satisfaction that has been shared by many other men who have used it. This method of treatment has been highly successful because it satisfies the two cardinal principles in the treatment of infection,—namely, adequate drainage and local and general rest. If the diseased process extends close to or involves the joint, there is another principle of treatment that is not made use of in the Orr treatment. In osteomyelitis the acute stage soon reaches the subacute and chronic stage, and it is becoming more and more recognized that the best stimulation to healing in a diseased joint is physiological motion. Even if the suppurative process does not involve the joint proper, there is apt to be considerable loss of motion of the joint with the affected limb immobilized in plaster for a great length of time. In the treatment of arthritis in the chronic stage, it is becoming well recognized that it is extremely important to obtain active motion of joints even at the expense of a long drawn-out fight for both patient and surgeon, a struggle that is often very painful during the first stages, but in the end is rewarded by a painless arc of motion and a degree of regeneration of joint structures that can never be obtained by prolonged immobilization.

Treatment in the salt-water pool embodies the cardinal principles of drainage and rest during the acute stage when there is pain and temperature, and in addition makes early use of a third principle,—namely, that physiological stimulation of a disorganized joint is the most important factor in joint regeneration and reestablishment of joint motion.

In addition to this, the warm salt-water pool has other distinct advantages. In the first place the warmth of the water has a very definite and well recognized beneficial effect in the treatment of any infection. Also, the water being strongly hypertonic, there is an osmotic pressure

* From the Clinics of the Orthopaedic Hospital-School.

existing between the body fluids and the salt water that creates an outflow of body fluid, which insures a regular and efficient washing and cleansing of the wound from its innermost depths. The practical demonstration of the truth of this principle has been shown many times in the treatment of deep, badly infected soft-tissue wounds. After a few daily salt pool treatments, these wounds clear up with surprising rapidity.

There is still another advantage in this type of treatment, an advantage that is more than imaginary. These patients, especially the older ones, become very tired of lying for months in ill-smelling casts, and when they begin daily treatment in the pool there is a distinct improvement in the morale. The treatments give them something definite and enjoyable to do, and when, in addition, they can watch the weekly improvement of

FIG. 1-A FIG. 1-B

Case 2. One week after operation. Notice that there is almost total absence of bony tissue for a distance of about two inches above the distal tibial epiphysis. In spite of this, motion of the ankle was started in the pool six weeks later, following which the drainage rapidly decreased.

their stiff joints and see their wounds become smaller and cleaner, the psychological effect is very evident.

In more detail, a case of osteomyelitis is handled as follows:

In the beginning the case is treated by the Winnett Orr method. The diseased bone is widely saucerized until healthy-appearing bone is encountered and the cavity and soft tissue lightly packed with vaselin gauze, and a plaster cast or spica applied. The length of time this cast is worn depends somewhat on the degree of bone destruction, the temperature and general appearance of the patient following operation, but, in general, for an average tibia or femur case, this cast remains for about a month. Then it is removed and daily pool treatment started, maintaining immobilization between treatments by means of bivalved casts or by

FIG. 2-A

FIG. 2-B

Case 2. Four months after operation. Notice the marked regeneration of bone in relatively short space of time. The wound is now completely healed and the patient is walking on crutches without weight-bearing on this leg. There is about thirty degrees of motion in the ankle.

light traction. During the first few treatments a splint is sometimes worn if it is not thought safe to begin motion of the involved joint.

The concentration of the salt in the pool is about six or seven per cent., which is a little stronger than average sea water, and, with this concentration, cultures of the water have always been sterile. The arc of motion of the involved joint, or the joints adjacent to the involved shaft, can be made greater and with much less pain than motion made out of water, and there is no reaction of pain after the patient is removed from the pool; in fact, the patient always says that the leg feels much better after treatment.

Later on in the course of treatment, when beginning of partial weight-bearing is indicated, the use of the pool is ideal. The dosage of weight passing through the lower extremities can be easily and accurately measured, since this weight is only the weight of the body above the water line. When weight-bearing is first started, the patient begins walking in the deeper water and gradually the depth of the water is decreased.

Up to date eleven cases have been treated. The first case was a suppurative arthritis of the knee joint with no bone involvement. This case responded so well to treatment that we began to use the same method with osteomyelitis and so far have been very favorably impressed with the results. In the suppurative arthritis case the knee was opened wide with a longitudinal incision on either side of the patella and fifty cubic centimeters of pus evacuated. The next five days the knee was irrigated with normal salt solution and motion started by using a Thomas splint with a movable knee. Following this the patient was put in the warm salt-water pool daily and motion encouraged. At the end of two months the contour of the knee was practically normal, both wounds had healed, and the patient had started to walk without crutches. There was complete extension of the knee and flexion blocked at eighty degrees. At three months postoperative the patient had a full range of painless motion, with the patella freely movable, and he was walking without limp.

The next case was osteomyelitis of the lower third of the tibia. An operation had been performed on the leg by another surgeon two weeks before admission to our hospital. The x-ray showed complete absence of bone in the lower two inches of the tibia just above the epiphysis except for a little bony debris. Proximal to this there was a loss of bony tissue on the medial portion of the tibia for a distance of another three or four inches. Upon admission the wound was packed with vaselin gauze and a long leg plaster cast applied. Six weeks later the patient was started with daily pool treatment, using the bivalved cast for a splint between treatments. The discharge decreased rapidly in amount and in two months the wound was completely healed. X-rays taken four months after operation show a remarkable growth of new bone, considering the loss of bony tissue as shown by the x-ray taken two weeks following operation. The patient at this time has about thirty degrees of ankle-joint motion.

FIG. 3

Case 3. Acute onset of osteomyelitis in neck of right femur. There is bone destruction on the lateral aspect of the neck just below the epiphyseal line and just below the greater trochanter. Large drill holes were made upward through the neck, starting below the trochanter in order not to contaminate the hip joint. Wound packed with vaselin gauze and a long leg plaster spica applied which the patient wore for three weeks, after which daily warm salt pool treatment was started.

FIG. 4

Case 3. X-ray two months later shows considerable bone regeneration. The patient has ninety degrees' flexion in the hip, twenty-five degrees' abduction, and over half the range of normal rotation without pain.

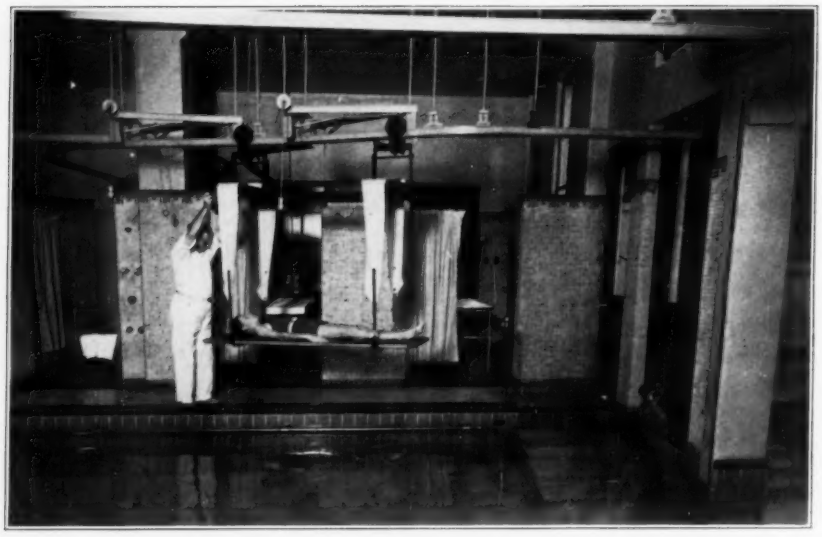

FIG. 5

Underwater gymnasium, Orthopaedic Hospital-School, Los Angeles, California. New method of handling recent and painful cases to and from the water.

Case 3. This was a sixteen-year-old boy who had an acute osteomyelitis of the left femur which was treated by Baer's maggot method. The wound was still draining when he suddenly began to have pain in the right hip with chill and high fever. The x-ray film showed an area of rarefaction just below the epiphyseal line of the capital epiphysis. There was also destruction of the lateral cortex of the femur beginning just below the greater trochanter and extending down the shaft for a distance of three or four inches. Six days after the clinical onset a femoral osteotomy was done and the neck of the femur drained by making large drill holes upward into the neck, starting below the trochanter in order not to contaminate the hip joint. The wound was packed with vaselin gauze and a long leg plaster spica applied. The spica was left on for three weeks during which time the temperature went up to 100 degrees daily. Light cuff traction to knee and ankle was then applied and daily pool treatment started. The temperature dropped to normal in a few days and the discharge rapidly decreased. X-rays of the hip two months later show definite bone regeneration and the wound healed except for one small point which was covered by excess granulations and was draining hardly at all. The patient at this time had no pain on motion of the hip and had almost ninety degrees of flexion, twenty-five degrees of abduction, complete adduction, complete internal rotation, and external rotation to a little past neutral position.

Eight other cases of osteomyelitis have been treated in this fashion, but it is too early to give end results. There were several patients in this group who were being treated by the Orr method who were still draining

moderately to profusely. In each case where the pool treatment was substituted there was a rapid diminution of drainage and a lowering of the temperature curve. One case now under treatment was osteomyelitis of the lower end of the tibia and fibula with involvement of the ankle joint. The ankle was laid wide open and packed with vaselin gauze and immobilized in plaster. The temperature gradually subsided, but within ten days there was a sudden rise of temperature with severe pain. The wound was then repacked under a general anaesthetic, and the temperature dropped again to almost normal and then suddenly became elevated again and the patient looked acutely ill. The plaster cast was then removed and daily pool treatment started. Within a week there was a marked diminution of pus, the temperature became normal and has remained so since; the patient is free of all pain, his appetite is good; and he looks like a different boy.

SUMMARY

Eleven cases of osteomyelitis have been treated in the warm salt-water pool. Theoretically, the principles of treatment seem sound and by actual practice the method has given worth-while results. It is particularly suited to those cases where the osteomyelitic process involves the joint or is in close proximity to the joint.

This method of treatment embodies and makes use of definite well recognized principles in the treatment of infection and joint regeneration,—namely:

1. Adequate drainage and immobilization. After the acute stage absolute rest is not maintained, but after the first month the plaster cast is removed and the patient immobilized in bed by light traction, by splints, or by bivalved casts. Daily pool treatment is then started, but even this is comparative rest, since motions in the pool are performed with a minimum of effort. No effort is exerted by the patient in getting in and out of the pool, since this work is done by an overhead electric traveling hoist with the patient lying on a stretcher.

2. Past experience in the treatment of suppurative arthritis has proven the proposition that physiological stimulation of a joint is the best means of insuring maximum return of motion in a diseased joint and a regeneration of joint structure. This principle is made use of in the salt-water pool treatment without jeopardizing the cardinal principle of rest.

3. The salt solution being strongly hypertonic, drainage of the infected tissue is accelerated because the difference in osmotic pressure existing between the solution and the body fluids causes an outflow of the latter from the diseased area.

4. Active movement in the water avoids the production of inhibitory spasm from pain or fear of pain as is usually produced by other forms of physiotherapy and muscle reeducation movements.

5. The treatment is soothing and is enjoyed by the patient, as compared with spending months of inactivity in ill-smelling casts.

FLEXION CONTRACTURE OF THE KNEE

The Mechanics of the Muscular Contracture and the Turnbuckle Cast Method of Treatment; with a Review of Fifty-Five Cases*

BY JACOB KULOWSKI, M.D., IOWA CITY, IOWA

Flexion contracture of the knee, like all other similar situations of the body involving the muscles, bones, joints, and ligaments, is subordinate to the same biophysical laws enunciated by Steindler in relation to the wrist and fingers. Its analysis involves a consideration of the concomitant gliding and rotatory motions of the joint that are an essential part of the normal mechanics of flexion.

The knee is the largest and most complicated joint of the body. It is a trocho-ginglymus, and allows rotation about a vertical axis, as well as flexion and extension. "Its peculiar anatomic construction is an expression of the very exacting static and dynamic requirements which it must meet, because of its situation between the hip and ankle joints in the middle of the weight-supporting lower extremity" (Steindler). It will be shown that the abnormal new point of muscular equilibrium, which is the position of contracture, is dependent upon the normal mechanics of the knee, and follows definite physical laws.

Flexion contracture of the knee presents postural deviations in the three cardinal planes of the body, as a rule. In the sagittal plane there is the predominant flexion position and the usual posterior subluxation of the tibia on the femur. The frontal plane abnormality expresses itself in increased valgus, while the external rotation of the tibia takes place in the horizontal plane.

1. *The Situation in the Sagittal Plane:*

The mid-position of the knee is in moderate flexion, in which attitude the muscles about the joint are nearest their point of equilibrium. There is then an inherent tendency of the joint to assume flexion, especially during relaxation. In full extension the hamstrings are under a stretch and are, for that reason, in the optimum condition for contraction. Reflex irritation therefore anticipates prevailing action of the hamstrings.

Clinically, and by hydrostatic experiments, it is known that the greatest capacity of the knee joint capsule is in the position of flexion. Excessive amounts of fluid in the joint will then naturally dictate the flexion posture.

In flexion of the knee the initial twenty degrees is a pure rocking motion, and is completed by a gliding motion of the tibia upon the femur. Subluxation of the tibia, therefore, occurs at some point of the gliding range of the joint.

* From the Department of Orthopaedic Surgery, the State University of Iowa, Service of Dr. Arthur Steindler.

2. *The Situation in the Frontal Plane:*

The knee normally has an appreciable valgus. Any increase of this angle is associated with the mechanogenesis of pathological external rotation. The tensor fasciae and the biceps femoris are external rotators of the knee; contracture of either or both tends also to increase the valgus.

The peripheral resistance incident to weight-bearing in the usual externally rotated position upon a flexed knee tends to increase the valgus. This is also remarkable in knee joints that have been fused by operation in the position of flexion. Many of these develop a valgus deformity, especially in children. A "closed kinetic chain" may result even from recumbency, because of the usual attitude of inward rotation of the thighs assumed by arthritics, who have more or less involvement of the lower extremity.

3. *The Situation in the Horizontal Plane:*

The biceps femoris acts upon the tibia through a longer lever arm than the internal hamstrings, because it is more distally inserted from the center of rotation of the knee, the vertical axis of which passes through the medial condyle of the tibia. The moment of the externally rotating forces is then the greater. Other factors favoring external rotation during flexion are: the relaxation of the ligamentous structures, the unwinding action of the crucial ligaments, and the loose attachment of the external meniscus.

It is, therefore, evident that the key to the contracture complex is the flexion position. The associated elements are secondary phenomena directly dependent upon it. The contracture position is, therefore, a fixed exaggeration of the normal flexion mechanics of the knee, incident to the newly established muscular equilibrium, and is certainly not a haphazard event.

Clinically, the contractures of the knee may be classified as:

1. *Arthrogenic.* This is by far the largest group as well as the most important one to be considered. Here are included all the contractures due to some primary joint pathology. The reflex irritations and hydrostatics are the predominant causes of deformity.

2. *Hypertonic.* Muscular imbalance, due to increased innervational impulses as in spastic paralysis and similar conditions, is the causal factor in this group.

3. *Paralytic.* This type is primarily due to muscular imbalance following paralysis or weakness of the antagonistic group, which in this case is the quadriceps. It may also be secondary to hip and ankle deformities.

4. *Congenital.*

5. *Postural.* These are secondary, due to static causes brought on by flexion contracture of the hip and disturbances of gastrocnemius function.

6. *Myositic.* This group is rare but may follow in the wake of

histopathological changes in the muscles from actual inflammatory involvement of the muscles.

The method of gradual correction of flexion contractures of the knee is indicated in the great majority of cases, and is actually effective. This view is amply supported by clinical and experimental observations upon muscular contracture. However, nothing is known of the biophysical properties of the capsular, nervous, and vascular structures which play such a prominent rôle in the posterior part of the knee. This naturally limits the application of conservative methods.

The importance of the posterior capsule in certain contractures of the knee cannot be overemphasized. Silver very aptly designated all the soft structures of the joint as the "surgical capsule".

Clinically, the block due to capsular shrinkage can be determined by the presence of a posterior springy resistance against passive extension of the knee in the presence of relaxed hamstrings. This has been confirmed at operation. In several such instances the complete relaxation of the muscles in the face of a markedly contracted capsule was remarkable. The muscles and tendons contiguous to the capsule do exhibit some shrinkage, while those more superficially placed are actually flaccid, even though they are a part of the same functional group. This is particularly true of the semimembranosus, because it has several broad aponeurotic insertions in and about the capsule. Similar observations, in principle, have been made in contractures of the hip joint.

The writer is convinced that capsular involvement precludes the mechanical method of correction by the present means at our disposal. In such cases the stripping of the capsule by the method of Silver or Wilson yields excellent results. Fortunately the capsule is, in most cases, the last structure to take part in the contracture. It is the writer's opinion that posterior capsular shrinkage does not occur in pure myogenetic contractures unless a very long period has elapsed. Among the many tenotomies that have been performed in this clinic, surprisingly few cases required additional capsulotomy. Actual inflammatory involvement of the capsule is the usual cause of capsular contracture, and such changes have been described in the literature.

Regarding the vascular and nervous structures even less can be said. If these cannot be accommodated to full extension, all corrective measures must be abandoned, save those that will shorten the extremity, as joint resection. But clinical experience teaches that, in practically all cases, these do respond to gradual correction.

Steindler called attention to the hypertrophied infrapatellar fat pad as a primary cause of flexion deformity, and anterior mechanical block to extension. In reviewing about sixty synovectomies performed in this clinic, the writer noted twelve cases of flexion contracture that resulted in full extension following operation.

The contra-indications to conservative gradual correction may be summed up as follows: (1) intra-articular adhesions and ankylosis, (2) all

varieties of internal mechanical blocks, (3) active joint disease, (4) posterior capsular shrinkage, (5) extreme structural changes in the hamstrings, and (6) local conditions of the skin that prohibit the application of force.

It is unreservedly admitted that operative procedures have a definite field of indication in the treatment of knee-joint contractures. Tendon lengthening, stripping of the hamstrings from their point of origin, juxta-articular osteotomies, arthroplasty, alcohol injections of the peripheral nerves, resection of the joint, capsulotomy, capsuloplasty, and tendon transplantation are necessary in selected cases. Some of these procedures merely place the joint in a more favorable position for action.

A word of caution relative to open operative and closed manipulative (redressment force) methods, upon arthrogenic contractures especially, is imperative. Many of these patients are elderly and are poor operative risks because of the general pathological changes underlying the local cause of invalidism. The atrophic condition of the bones favors post-operative infection and fracture. Several such instances of infection with erosion of the popliteal vessels have been observed. Two cases of fat embolism resulted from the fractures incident to manual corrective attempts.

Autopsy examinations revealed extensive parenchymatous pathological changes, the occurrence of which is too often overlooked in chronic arthritis. These cases combine all the optimum conditions for fat embolism in orthopaedic manipulations. The initial force drives the fat into the numerous vascular channels, because abundance of fat and vascularity are both characteristic of atrophic bone. In one case the fragility of the bones was dramatically demonstrated at autopsy, when the long bones were fractured with a minimum of effort. This complication is so insidious that it is often unsuspected until the symptoms of embolism make their grim appearance. Primary manipulation of arthritic joints has not been performed in this clinic for the past ten years.

The many mechanical appliances that have been devised for the gradual correction of flexion contractures of the knee are a tribute to conservatism. Those in use by Campbell, Smith, Lord, and others have much to recommend them, but usually require the construction of special apparatus. Their chief feature is directed against posterior subluxation already present, and its prevention during treatment. Juckelson states that the turnbuckle of Hackenbruch (*Distraktionsklammer*) was introduced in connection with the lower extremity in 1913. All joint contractures are treated by the turnbuckle method in this clinic wherever feasible. The elbow and the knee are by nature best adapted to this method.

The knee is situated in the center of two long levers with the joint as the axis of rotation. The turnbuckle-cast method depends upon the principle of three-point application of force. The principles of the second-class lever are utilized. It is absolutely essential that the joint remains the axis of motion of the system. The leg is considered to be the movable body. The moment of leverage is dependent upon the amount of force

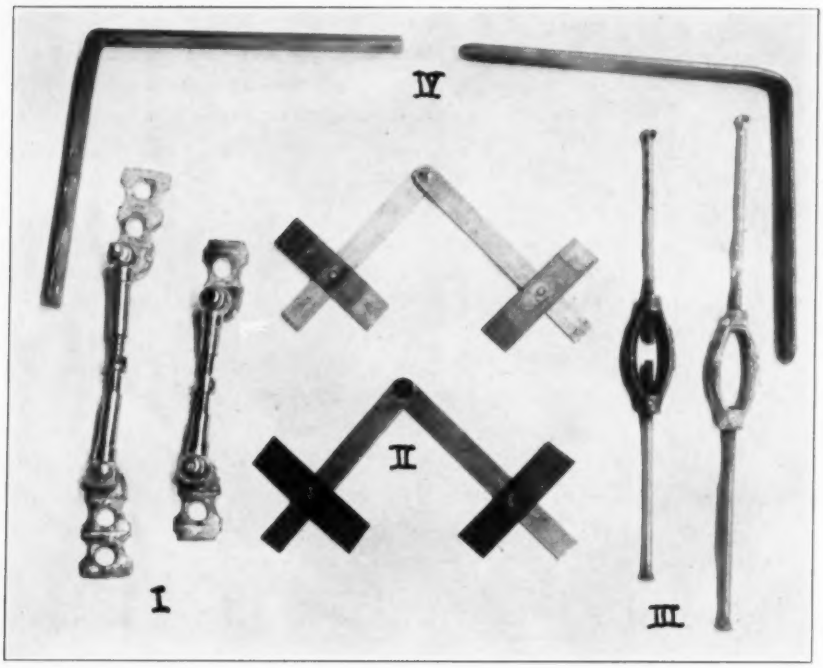

FIG. 1

I. Hackenbruch type of turnbuckle, which has ball and socket joints at the junction of the flanges and posts. Both halves are united by a sleeve-screw device which is perforated to allow insertion of lever for turning the turnbuckle.

II. Steel hinge with band on each end.

III. Ordinary buck-saw type of turnbuckle. (A windlass arrangement may be used.)

IV. Piece of cold rolled steel, three-sixteenths by seven-eighths inches, bent at right angles.

the angle of application, and its perpendicular distance from the center of rotation. The resistance to be overcome is the hamstring contracture as well as the weight of the leg. The possibility of initiating posterior subluxation (or increasing it, if it is already present) of the tibia must be considered in the practical application of this method.

If the force is applied distal to the insertion of the hamstrings and its resistance cannot be overcome, their point of insertion will become the center of rotation, with a resultant posterior dislocation of the upper end of the tibia.

When the resistance of the hamstrings is overcome, the center of rotation remains at the knee joint, and the leg rotates forward. The incorporation of hinges into the cast serves to maintain the center of motion at the joint. The correcting force resolves itself into a forward and a traction component. If a sliding type of hinge is used, the latter component may be utilized with advantage upon arthritic joints.

Mechanically, as correction proceeds, it becomes more difficult to overcome the resistance due to the decreasing angle of application. This

contingency is met by placing the turnbuckles anteriorly, fixed to uprights incorporated in the cast. In this way a better purchase is obtained for the last few degrees of correction (Quengel method of Mommsen). Eccentrically placed turnbuckles easily overcome the external rotatory deformity before the hinges are included in the cast. By placing the hinges behind the center of motion of the knee, a forward thrust is exerted upon the upper border of the tibia, which tends to correct the subluxation.

The turnbuckle-cast method, in its several parts, is extremely simple. As a method of systematic procedure, attention to details is essential to obtain the best results.

The patella offers the counter-pressure to that which is applied posteriorly upon the thigh and leg. These areas require adequate protection. Special care is taken about the heel. A long leg cast is applied from the groin to the toes. Where considerable resistance is anticipated, a hip spica will serve to fix the thigh more firmly. A light, well-molded cast will favor weight-bearing early in the treatment. To minimize the resistance sometimes offered by the gastrocnemius, the foot may be fixed in equinus.

When the plaster has hardened sufficiently, it is divided all around the knee, leaving a tongue from the thigh portion snugly over the patella to insure a more even distribution of pressure over this area. In those cases where the subluxation and external rotation are negligible, the hinges and turnbuckles are incorporated into the two parts of the cast with the center of the hinges and the knee coinciding (center of the femoral condyles). Correction is exercised only within the tolerance of the patient, who in many instances soon learns to continue independently at home. Weight-bearing is encouraged just as soon as the plaster is hard enough, either with crutches, or in the gymnasium with the further aid of apparatus.

Retentive braces are worn for at least six months following correction to prevent recurrence of the contracture. In many cases the joints are insufficient to bear weight without support, because of the underlying joint pathology. An existing flexion contracture of the hip will be a factor in causing a recurrence, and must be corrected also. The same holds true for marked gastrocnemius weakness. In both situations locomotion induces a flexion position of the knee in order to satisfy gravital stresses. In some arthrogenic cases there remains a slight residual flexion deformity. This may be finally overcome by applying short skis to the shoes. This will allow the center of weight to be displaced forward, in the upright position, which will exert a correcting stretch upon the posterior structures of the knee.

There are those who offer the following objections to this method: decubitus ulcers, joint stiffness, atrophy, reactivation of the joint pathology, and vascular and nervous disturbances.

Pressure complications can all be avoided by careful application of the cast. Immediate examination of the part causing complaint may

prevent disappointment and alleviate suffering. It may be axiomatically stated that a definite decubitus is already present when the patient complains of actual pain. In our series these were rare and superficial.

Joint stiffness and some limitation of motion is usually primarily present in the arthrogenic type. The postcorrective range of motion will depend upon the degree of joint destruction underlying the disability. Cast stiffness is minimized by having the patient execute the turnbuckle excursion daily. In the pure myostatic cases there should be no limitation of the joint motion, because the recovery of the normal length of the muscle fiber is effective and physiological by this method.

Muscular atrophy is also a usual accompaniment of arthrogenic contractures, and may be a factor in lessened resistance to correction. Daily active tension of the quadriceps and weight bearing do much to prevent progressive wasting. The duration of the cast period must be considered, and, in some instances, may be prolonged enough to warrant caution in this respect. The method of gradual correction gives the stretched extensors of the knee an opportunity to regain their normal tone. It has been observed that active insufficiency of the quadriceps has resulted from sudden correction, in several cases.

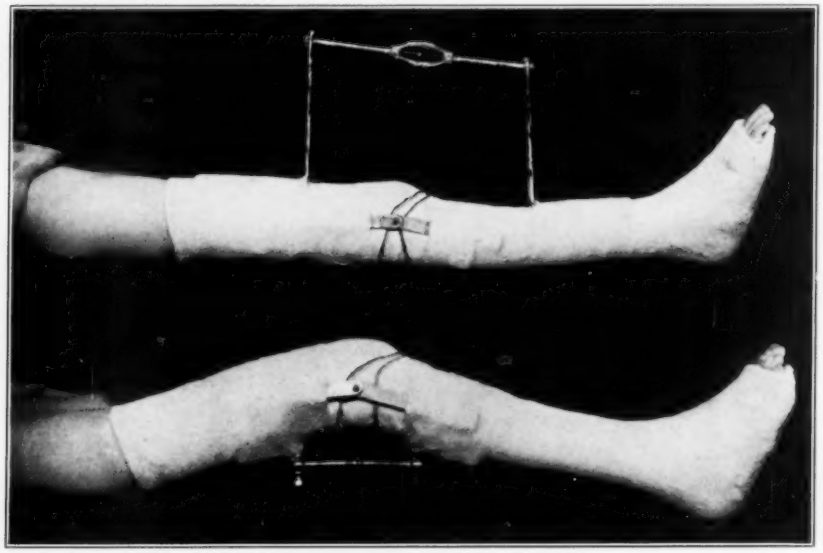

FIG. 2

The upper figure shows the regular type of turnbuckle cast employed for obtaining the initial correction. In the great majority of cases full correction is obtained in this manner. The only changes that are required concern the reapplication of the turnbuckles after their full excursion range has been reached. It is seldom necessary to change the original cast.

The lower figure represents the Quengel method, which is used in those cases offering considerable resistance to the terminal stages of correction.

Following complete correction, posterior plaster splints are applied until the braces are fitted; in the meantime, the patient is ambulatory, and receives physiotherapy.

Reactivation of the joint pathology is seldom noted in properly selected cases. Its occurrence suggests that the joint was unsound at the outset of treatment. It is our custom to apply balanced traction to all cases exhibiting signs of activity, as a preliminary measure. Balanced traction will not in itself correct an actual contracture, but serves to overcome the muscle spasm due to some activity of the joint pathology.

Vascular and nervous disturbances were not observed in this series. Because there have been some definite reports of this in the literature, it is well to bear this possibility in mind. This complication should be feared much more in all the sudden corrective procedures. In those severe contractures that required operation it was never possible to obtain the full correction at once, due to the tension exhibited by the external popliteal nerve, which may also be taken as the index of the vascular tension. These were all finally corrected by the effective application of a turnbuckle cast.

CLINICAL DISCUSSION

Fifty-five cases have been treated by the turnbuckle-cast method, which includes fully seventy-seven knee contractures. There were twenty-three male and thirty-two female patients, in forty-six of whom the contractures were completely corrected. The average duration of the contracture was two and twenty-nine hundredths years, which is taken from the patients' statements, and must be considered with reservations; the actual time was in all probability less. The average time required to obtain full correction was thirteen and ninety-eight hundredths days. The average amount of contracture was thirty and forty-seven hundredths degrees. It is regrettable that the amount of deformity in the secondary planes was not recorded beyond a confirmation of their presence.

The arthrogenic group includes eighty per cent. of the total number. Twelve of these were over fifty years of age, and were in very poor general condition. Sixteen were total invalids at the beginning of treatment, and twenty exhibited multiple deformities. Most of them are now ambulatory, with or without some degree of mechanical support. In the great majority of those who had good motion before treatment, functional activity followed the removal of the casts.

Eight cases were not corrected. Three of these are still under treatment. Three had definite capsular shrinkage, one of which came to operation. This was a contracture of five years' duration incident to an osteomyelitis of the upper end of the tibia. The flexion was overcome from 100 degrees to 150 degrees after persistent turnbuckle correction. The posterior capsule was then stripped according to the technique of Wilson, and was found to be greatly thickened and even adherent to the posterior crucial ligament. Correction progressed to 165 degrees, the tension of the external popliteal nerve prohibiting further extension. When the wound was healed, a turnbuckle cast was effectively applied. It was then found that the old lesion had become reactivated, which

necessitated drainage through an opening in a long leg cast, by the Orr method; this method maintained the corrected position. It is the opinion of the writer that the operative interference which necessitated exposure of the posterior part of the joint was the causal factor in the reactivation of the old osteomyelitic process.

An intercurrent infection interrupted the treatment in one case. In another a metastatic suppurative process, secondary to a boil on the neck, necessitated Orr drainage of the contracted joint. Thanks to this method of drainage, the amount of correction thus far obtained has not been lost, and a functional position of the knee has been retained.

In connection with the arthrogenic types of contracture, it may be stated that actual intra-articular adhesions are a rare occurrence. This has been impressed upon the writer by Dr. Steindler. Of the many knee joints that have been explored, relatively few have exhibited definite fibrous adhesions. This condition as a contra-indication to gradual correction has, therefore, been grossly overestimated.

Twelve of the earlier cases in the series were treated while some signs of joint activity were still present, without complications other than moderate discomfort. There were seven superficial heel and patellar ulcers that responded readily to treatment. Active foci of infection must be taken care of. In one case the presence of an infected unguis incarnatis caused joint pain, which ceased after the local infection was removed surgically.

The arthrogenic contracture, clinically, increases its resistance as

TABLE I

Classification	*Total number of cases*	*Total corrected*	*Average duration of contracture in years*	*Average amount of contracture in degrees*	*Average duration of treatment in days*
1. Arthrogenic:					
Chronic arthritis	27	24	4.40	41.80	29.30
Suppurative arthritis	4	3	2.80	39.00	13.50
Traumatic arthritis	5	4	0.33	43.70	23.00
Gonorrhoeal arthritis	8	5	0.52	35.00	17.40
	44	36	3.47	39.87	20.95
2. Paralytic	5	5	1.00	30.00	14.00
3. Hypertonic	3	3	0.34	37.50	14.00
4. Congenital	2	1	6.00	30.00	?
5. Postural	1	1	0.66	15.00	7.00
	55	46	2.29	30.47	13.98

Clinical analysis of fifty-five cases of flexion contracture of the knee joint, which includes seventy-seven contractures, treated in this clinic by the turnbuckle-cast method of gradual correction. The low, apparent incidence of capsular shrinkage is strikingly borne out by the fact that, of four cases due to suppuration of the knee, three were successfully corrected by this method. The gonorrhoeal group is also remarkable in this respect.

correction progresses. This is especially true in all types of contracture after actual shrinkage has occurred.

The opposite obtains for the hypertonic type of contractures. The initial resistance is the greatest, but when that is overcome, it soon yields to complete correction. The tendency to recurrence is inherent in the spastic contracture. Theoretically, because spastic contractures are labile, they may, under favorable conditions, be induced to reverse themselves. In the upper extremity the condition of "spasmus mobilis" is not uncommon, and has been observed in this clinic. Spastic extension contracture is rare in the lower extremity, but is always induced experimentally in the laboratory by the use of tetanus toxin. It is to the latter investigations that we owe most of our knowledge concerning contracture of muscles. Several hypertonic cases that have been corrected are being retained in extension in casts, in the hope that reversibility, in some degree, may be obtained. It should be remembered, in this connection, that while the genesis of contracture is dependent upon the higher centers and the integrity of the local reflex arc, it is entirely independent after actual contracture has taken place.

Congenital knee contracture can be corrected if attacked early. A case that could not be corrected by gradual extension is of particular interest. This boy presented bilateral marked spastic contractures incident to an extensive spina bifida occulta of the lower dorsal spine. Conservative treatment begun about ten years after birth was ineffective. The child had never walked, and both knees were in 140 degrees of extension at the time of operation. A posterior capsuloplasty, combined with tenotomy and lengthening of the tensor fasciae femoris and all the hamstrings, resulted in 160 degrees of extension. Here again the turnbuckle cast was effective in completely correcting the remaining deformity in about three weeks.

The postural and the paralytic types may be considered together. The results of treatment by gradual correction were excellent. Due to the unopposed action of the tensor fasciae femoris, which so frequently escapes paralysis, the paralytic type of knee contracture is usually remarkable for the degree of valgus and external rotation, which, in extreme cases, may require additional osteotomy. In this group it is especially important to correct all associated deformities and deficiencies, in order to prevent recurrence. The presence of strong glutei and gastrocnemius will exert an extensor thrust upon the knee during locomotion. In recumbency the latter may favor flexion and recurrence.

CONCLUSIONS

Flexion contracture of the knee follows definite physical laws, which apply to all muscular contractures, and is modified by its peculiar anatomical construction.

Gradual correction by the turnbuckle-cast method is offered as the method of choice, in the great majority of cases, because it has proved to

be actually effective in a series of cases, including seventy-seven flexion contractures of the knee joint treated in this clinic. It provides a rigid system, which is so essential for the application of a correcting force upon the largest joint in the body. It may be universally applied, and does not require the construction of special apparatus. It is a method that is urged as a primary procedure, but its further utility preliminary or secondary to operative measures should not be overlooked. Its early application is especially indicated in contractures following actual involvement of the joint, before capsular shrinkage has occurred. As a preventive means, turnbuckles may be incorporated into every cast applied upon a pathologically flexed knee, in order to encourage correction just as soon as activity subsides. In this way even cases of tuberculosis of the knee may be given a better functional position.

The writer wishes to express his appreciation of Dr. Steindler's enthusiastic encouragement, valuable guidance, and his correction of the manuscript.

BIBLIOGRAPHY

Allenboch, E.: Contracture Spastique des Membres Inférieurs par Spina Bifida Occulta. Opération. Guérison. Rev. d'Orthop., XIV, 347, 1927.

Bolling, L. A.: Limitation of Joint Function in Long Bones; Prophylaxis and Correction; Demonstration of Subject with Apparatus. Internat. J. Med. and Surg., XLI, 123, 1928.

Bowen, W. P.: Applied Anatomy and Kineseology. Ed. 4. Philadelphia, Lea and Febiger, 1928.

Calonge, S. D.: Treatment of Fibrous Ankylosis of Knee and Elbow Joints. J. Am. Med. Assn., LXXXIX, 1427, 1927.

Campbell, W. C., and Mitchner, J. M.: An Apparatus for the Correction of Flexion Contracture of the Knee. J. Bone and Joint Surg., VIII, 416, Apr. 1926.

Clarke, B. E.: Fat Embolism. A Report of Two Fatal Cases Following Orthopedic Manipulations. J. Am. Med. Assn., LXXXVIII, 919, 1927.

Cravener, E. K.: Device for Overcoming Non-Bony Flexion Contractures of the Knee. J. Bone and Joint Surg., XII, 437, Apr. 1930.

Davenport, H. A., Davenport, H. K., and Ranson, S. W.: Chemical Studies of Muscle Contracture. I. The Lactic Acid Content. J. Biol. Chem., LXXIX, 499, 1928.

Chemical Studies of Muscle Contracture. III. The Change in Glycogen During Shortening Produced by Tetanus Toxin. J. Biol. Chem., LXXXII, 499, 1929.

Chemical Studies of Muscle Contracture. IV. Changes in Phosphorus, Nitrogen and Fat Produced by Tetanus Toxin. J. Biol. Chem., LXXXVII, 295, 1930.

Davenport, H. K., and Ranson, S. W.: Contracture Resulting From Tenotomy. Arch. Surg., XXI, 995, 1930.

Davenport, H. K., Ranson, S. W., and Stevens, E.: Microscopic Changes of Muscle in Myostatic Contracture Caused by Tetanus Toxin. Arch. Path. and Lab. Med., VII, 978, 1929.

Davis, L., and Pollock, L. J.: Studies in Muscle Tone. II. Resiliency of Muscles in Decerebrate Rigidity. Am. J. Physiol., LXXXIX, 395, 1929.

DeGuy, M.: Appareils à Extension Continué pour Fractures. Paris Méd., XXIII, 43, 1917.

Dixon, H. H., Davenport, H. A., and Ranson, S. W.: Chemical Studies of Muscle Contracture. II. The Distribution of Phosphorus in Frog Muscle During Delayed Relaxation. J. Biol. Chem., LXXXII, 61, 1929.

DUCROQUET, JR.: Redressement Progressif des Déformations du Genou chez l'Enfant. Bull. Soc. de Pédiat. de Paris, XXVII, 201, 1929.

EIKENBARY, C. F.: The Problem of Ankylosed or Partially Ankylosed Joints. Northwest Med., XXVII, 575, 1928.

FICK, R.: Messungen und Betrachtungen über die Muskelfaserlänge bei Muskelschrumpfung. Wiener Arch. f. Inn. Med., X, 471, 1925.

Übersicht über die Fragen der Gelenk- und Muskelmechanik. Ztschr. f. Orthop. Chir., LI, 320, 1929.

FISHER, A. G. T.: Manipulative Surgery, Principles and Practice. New York, The Macmillan Company, 1926.

Indications for Manipulative Surgery. Bristol Med. Chir. J., XLV, 165, 1928.

FLAGSTAD, A. E.: Traction Apparatus Used in Correcting Equinus Deformities. J. Bone and Joint Surg., VIII, 718, Oct. 1926.

GOLDTHWAIT, J. E.: The Forcible Straightening of Angular Deformities of the Knee, by Means of Special Mechanical Appliances. Boston Med. and Surg. J., CXXVII, 517, 1892.

HASS, J.: Wann und Wie Sollen Versteifte Gelenke Mobilisiert Werden? Wiener Klin. Wchnschr., XLI, 406, 1928.

HEYMAN, C. H.: Manipulation of Joints. J. Bone and Joint Surg., XII, 23, Jan. 1930.

HINSEY, J. C., AND GASSER, H. S.: The Component of the Dorsal Root Mediating Vasodilatation and the Sherrington Contracture. Am. J. Physiol., XCII, 679, 1930.

JAEGER, C. H.: Flexion Deformity of Knee, an Improved Method of Correction. Am. J. Surg., XXX, 15, 1916.

JAYLE, F., BACQUELIN, P., ET DUBÉ, T.: La Tension Elastique Continué pour le Redressement des Attitudes Vicieuses des Membres. Presse Méd., XXIV, 481, 1916.

JENSEN, E.: Case of Flexion Contracture of Knee-Joint (90°) Straightened by Mommsen's Method. Ugesk. f. Laeger., LXXXIX, 1200, 1927.

JUCKELSON, M. B.: Die Streckung von Kniekontrakturen vermittels Hackenbruch'scher Distraktionsklammern. Zentralbl. f. Chir., LII, 1946, 1925.

KELLER, C. J.: Untersuchungen über die Tetanusstarre. Ztschr. f. Biol., LXXXVII, 345, 1927–28.

KRONE, W.: Gipsverbände und Operationen bei Rheumatischen Arthritiden. Münchener Med. Wchnschr., LXXVI, 1378, 1929.

LINDHARD, J., AND MÖLLER, J. P.: On the Elasticity of Skeletal Muscles. Skandinavisches Arch. f. Physiol., LIV, 41, 1928.

LORD, J. P.: Contractures of the Knees, with Demonstration of Appliances. Nebraska Med. J., XII, 26, 1927.

LOWMAN, C. L.: Rotatory Subluxation at the Knee. J. Bone and Joint Surg., VI, 827, Oct. 1924.

MARAGLIANO, D.: Il Trattamento delle Contratture Artrogene del Ginocchio Coll'-alcoolizzazione Parziale dello Sciatico. Chir. d. Org. di Movimento, V, 659, 1921.

MASLAND, H. C.: A Corrective Device for Soft Tissue Contractions of the Knee and Elbow Joints. Am. J. Surg., III, 592, 1927.

MOSER, E.: Künstliche Muskelerschlaffung. Med. Klin., XVIII, 791, 1922.

NICHOLS, E. H., AND RICHARDSON, F. L.: Arthritis Deformans. J. Med. Research, XXI, 149, 1909.

OSGOOD, R. B.: A Method of Osteotomy of the Lower End of the Femur in Cases of Permanent Flexion of the Knee-Joint. Am. J. Orthop. Surg., XI, 336, Oct. 1913.

The Orthopaedic Aspects of Chronic Arthritis. J. Bone and Joint Surg., VIII, 1, Jan. 1926.

OVERGAARD, J.: Kontrakturenbehandlung. Münchener Med. Wchnschr., LXIII, 1671, 1916.

PARKER, C. A.: Treatment of Pathologically Flexed Knee. J. Am. Med. Assn., LXXXI, 1198, 1923.

Pollock, L. J., and Davis, L.: Muscle Tone. I. Extensibility of Muscles in Decerebrate Rigidity. Arch. Neurol. and Psychiat., XXI, 19, 1929.

Ranson, S., and Ranson, S. W.: Recovery from Myostatic Contracture Caused by Tetanus Toxin. Arch. Path. and Lab. Med., VII, 949, 1929.

Ranson, S. W.: The Elasticity and Ductility of Skeletal Muscle. Am. J. Physiol., LXXXVI, 302, 1928.

Local Tetanus. Arch. Neurol. and Psychiat., XX, 663, 1928.

Ranson, S. W., and Sams, C. F.: A Study of Muscle in Contracture: The Permanent Shortening of Muscles Caused by Tenotomy and Tetanus Toxin. J. Neurol. and Psychopath., VIII, 304, 1928.

Schmidt, J. E.: Zur Behandlung der Beugestellung bei Knieankylose durch Keilumpflanzung. Zentralbl. f. Chir., XLIX, 1243, 1922.

Silver, D.: The Rôle of the Capsule in Joint Contractures: with Especial Reference to Subperiosteal Separation. J. Bone and Joint Surg., IX, 96, Jan. 1927.

Smith, L. D.: A Knee Straightening Device. J. Bone and Joint Surg., VII, 206, Jan. 1925.

Spannaus, K.: Praktische Neuheit auf dem Gebiete der Extensionbehandlung. Zentralbl. f. Chir., LII, 801, 1925.

Speed, K.: Transarticular Capsulorrhaphy. Surg. Clin. Chicago, II, 701, 1918.

Steindler, A.: Synovectomy and Fat Pad Removal in the Knee. J. Am. Med. Assn., LXXXIV, 16, 1925.

Operative Orthopedics. New York, D. Appleton and Co., 1925.

The Mechanics of Muscular Contractures in Wrist and Fingers. J. Bone and Joint Surg., XIV, 1, Jan. 1932.

Lectures in Advanced Kineseology. (Unpublished.)

Stracker, O.: Zur Dauerapparatbehandlung von Nervenverlatzungen. Münchener Med. Wchnschr., LXIII, 1738, 1916.

Swaim, L. T.: The Orthopaedic Principles in the Treatment of Chronic Arthritis. J. Bone and Joint Surg., VIII, 845, Oct. 1926.

Tretter, H.: Beiträge zur Mechanik des Kniegelenkes. Deutsche Ztschr. f. Chir., CCXII, 93, 1928.

Vance, B. M.: The Significance of Fat Embolism. Arch. Surg., XXIII, 426, 1931.

Wilson, P. D.: Posterior Capsuloplasty in Certain Flexion Contractures of the Knee. J. Bone and Joint Surg., XI, 40, Jan. 1929.

Young, C. C.: The Rôle of the Tensor Fasciae Femoris in Certain Deformities of the Lower Extremities. J. Bone and Joint Surg., VIII, 171, Jan. 1926.

INTERMITTENT HYDRARTHROSIS

BY JOHN LINCOLN PORTER, M.D., AND ROBERT C. LONERGAN, M.D.

EVANSTON, ILLINOIS

Intermittent hydrarthrosis is a rare affection of the joints in which the periodic swelling is the most characteristic feature. It has been described by several authors under such synonyms as quiet effusion, intermittent hydrops, intermittent synovitis, recurrent synovitis, and hydrops intermittens articulorum.

Moore, in 1864, was the first to identify the condition, although one or two papers which preceded his quoted cases of obviously the same syndrome. As these papers and case reports which followed the original identification are studied, one can see a gradual accumulation of facts which help to complete the picture; yet there is still considerable speculation as to the cause and treatment. Moore's first case followed an attack of ague and was marked further by a remission, beginning with the third month of pregnancy and continuing up to the third month of lactation, when the periodic effusion returned in its former vigor. The case was treated unsuccessfully with various medications, among them arsenic. Arsenic in one form or another has been used, up to and including cases reported by Brackett in 1901 and Marsh in 1905. There is, however, no unqualified approval of its use or that of other medications. Such cases have been treated with quinin and its derivatives, and earlier reports naturally suggested a relationship to malaria. However, this has not been demonstrated. Brackett states that malaria might have something to do with a liability to the disease. He also says that a vasomotor neurosis is the most accepted theory of the causation. In many instances the literature suggests a relationship to angioneurotic oedema. Hildebrand pointed to "the intimate anatomic relationship of the extensive circulation of the knee joint and the nervous system, permitting the assumption that transitory influences acting through either might produce the syndrome". It may seem that the knee joint is an important consideration, for, according to Bierring, it is affected in every reported case.

Schlesinger noted a similarity to angioneurotic oedema and in a recent report presented observations on the occurrence of hydrarthrosis in five members of a family, two of whom also suffered from oedema of the mucous membrane of the mouth, and one from asthma.

Naturally such an assumption brings up the question of hypersensitivity, a feature in the report of Miller and Lewin. On this basis they tried to desensitize a patient with an injection of peptone. This was followed promptly by a marked urticaria, from which it was concluded that the patient was hypersensitive. Subsequent treatment by intra-

venous injections of dead typhoid bacilli rendered the attacks milder in character, and, according to reports some six months later, there was a complete cessation. The fact that remissions characterize this disease offers a difficulty in qualifying any reported clinical cure. Certain points of similarity to Lewin's case will be shown later in this article. Miller and Lewin state that it is open to question whether the results quoted were due to a non-specific desensitization or merely the effect of a foreign protein injection. In this connection, one must also recall the cessation of attacks cited in the first report by Moore during the course of pregnancy.

Two types of intermittent hydrarthrosis are generally recognized, which in current medical usage may be termed idiopathic and symptomatic. The first is described by Lovett, and also by Whitman, as a painless intermittent synovitis occurring usually in young adult females, and is probably related to menstrual irregularities, whereas the second, or symptomatic type, seems to be definitely associated with arthritis deformans.

For instance, Pemberton, in discussing Bierring's paper, states that he believes the condition to be part of the arthritic syndrome at large. In 1921 Bierring reported a case and published with it a complete bibliography containing the known seventy-six cases which preceded his. This survey brought out certain features. In all the reported cases one or both knee joints were involved. The incident was equally divided between the sexes, and pregnancy brought a remission of symptoms during its course. The longest interval was thirty days, the shortest two days. He, as other authors, calls attention to the occasional long remissions.

Bierring suggests that the circulation may be involved, and he feels that there is a strong tendency to associate the phenomena with vasomotor disorders even though many cases have arthritis in the background. The consensus of opinion seems to be that this is a vasomotor disorder, and as such it must presume the question of hypersensitivity.

The presentation of this case report is in its entirety, because of the detailed study of an unusual condition and because the many interesting features which developed seemed to justify it. The patient, a Scotchman and a physician, has so aptly described his plight that it may well serve as a text. The following is quoted from his own statement:

"Toward the end of the year 1917, when aged thirty-three, and while serving with the British troops in France and Flanders, I awakened to the fact that my right knee was subject to attacks of swelling, accompanied by pain from time to time. I accordingly determined to keep the joint under observation and by recording the dates of these periodic swellings found that the attacks were occurring every twelve days.

"Knowing an attack to be due on a certain day, I soon became expert at detecting almost the exact minute of the onset, especially if the onset occurred during walking. I would suddenly experience a slight stiffness of the joint and realize that my strides had become a little bit shorter. Once begun, the stiffness would gradually increase, the knee

swell, and, since the attacks varied somewhat in severity, pain would be present with impairment of mobility in proportion to the extent of the swelling; the swelling would be manifest within about two hours, and by the end of the first day the patella would be floating. The distention would attain its maximum at the end of two days, and within a half hour of its commencing to recede relief would be obtained. By the end of the third day the joint was again normal and no inconvenience felt until the commencement of the next attack.

"The knee was never red nor hot during an attack, nor was there any elevation of temperature. I have, however, on occasion during a severe attack, shivered and felt cold for about an hour preceding the subsiding of the swelling, but my temperature remained unaffected. The periodicity and severity of the attacks were uninfluenced by my daily routine, the seizures arriving invariably time to time, irrespective of the amount of rest or exercise taken between the quiescent periods of the disease.

"At the beginning of the year 1919 my left knee became similarly involved, the seizures, though always of less severity, recurring every twelve days and persisting for three, but alternating with those of the right. Only on perhaps two or three occasions during almost nine years have both knees been affected simultaneously."

In 1921 the patient contracted pneumonia, and following that illness there was a complete remission of symptoms for four months. During the year 1922 the intervals became shorter, and at the end of the year the cycle was a ten-day one. The interval was further curtailed during October, 1923, to nine days. In the early days of the malady the knees returned to normal size, but as time went on a chronic swelling had developed, which never receded, and normal range of motion was lost.

In September, 1923, pain developed in the lumbar spine, which has never completely left. The patient has also noted an increasing loss of mobility in the entire spine.

After a consultation in London, in 1924, the lower teeth were removed and a vaccine prepared from the roots. This was injected intramuscularly, and the patient took calcium and parathyroid extract by mouth. This treatment ameliorated the symptoms to a marked degree, so that the attacks became less severe, the periodicity was upset, and there was a total remission for one month (September, 1924). The following course was marked by a gradual return, until in March, 1926, the attacks were again occurring at nine-day intervals and lasting three. The spine and knees presented an increased swelling, pain, and disability. The patient noticed, however, that the attacks in the knees were never as severe after the vaccine treatments.

The patient was admitted to the Evanston Hospital on September 17, 1927, being forty-three years old at that time. Apart from childhood diseases the patient had had no other illnesses except a Neisser infection in 1906. This was followed within a short time by an acute gonorrhoeal rheumatism. The left knee and the right ankle were affected chiefly, and the patient was confined to bed for eight weeks. A complete recovery ensued, without any evidence of joint impairment.

Physical Examination

The doctor was a man weighing about 170 pounds and walking with the aid of a cane; both knees were flexed; and there was a definite forward stooping at the hips. There was also present a round-shoulder deformity. Motions were performed carefully and any extreme was painful. The head and neck were held rigidly, and the cervical spine was obviously stiff.

Head: Eyes reacted normally; vision was good. The antra transilluminated well and uniformly. The tonsils were of fair size, sclerotic, and considerable caseous pus was expressed on deep pressure. Anterior pillars were red and thickened. Patient wore upper and lower dentures.

Neck: Neck was held rigidly, thrust forward, and motions were limited and painful in all directions.

Chest: Well formed; expansion fair. There was no apparent fixation of the ribs. Lungs were clear to auscultation and percussion. Heart was not enlarged; no murmurs.

FIG. 1

Roentgenogram of both knees in the anterior-posterior positions, showing the characteristic changes of an advanced osteo-arthritis.

FIG. 2

Roentgenogram of the right knee joint, lateral view, showing lipping of the joint margins, marked diminution in the joint space, and changes in the contour of the joint.

FIG. 3

Lateral view of the left knee joint.

Pulse was soft, regular, and smooth; heart action low in power; capillary circulation poor.

Pulse 80. Respiration 18. Blood pressure 100/66.

Temperature varied during hospital course, but the average was about 98 degrees.

Back: Lumbar spine was flat; dorsal curve was accentuated. Motions were definitely limited in all directions and painful if forced. Deep pressure along spine was painful, especially along the lumbar spine.

Abdomen: Soft. No muscular tone. Pendulous, with rather large fatty panniculus. Intestinal musculature of poor tone. Liver enlarged moderately. No masses or tenderness. Sensitive on deep pressure over spine anteriorly.

Genito-urinary: Prostatic massage revealed a number of pus cells.

Joints: No departure from normal except the above described spine and the knees.

Right knee: Diffusely swollen, obscuring bony landmarks and outlining clearly the quadriceps pouch. The increase was also apparent in popliteal space. The swelling did not fluctuate but was felt as a soft, boggy mass of tissue surrounding the joint. No extremely sensitive areas. The knee was held in from fifteen to twenty degrees' flexion. Flexion was limited to right angles and motion beyond this point or to complete extension was exquisitely painful. During the period of attack the joint became even more swollen and painful and was characterized by a tenseness which offered definite resistance to pressure in contrast to the previous soft pultaceous swelling; it did not pit, however. The superficial veins were dilated.

Left knee: Relatively the same, but much less in degree; motion was of greater extent and the deformity less marked.

Laboratory Examination

Urinalysis: Acid; specific gravity varied from 1.008 to 1.022; faint traces of albumin uniformly present; sugar negative; indican negative.

FIG. 4

A synovial membrane showing hypertrophy of surface cells, a narrow oedematous subsynovial zone and infiltration of deeper tissues with round cells. (16 millimeters' objective.)

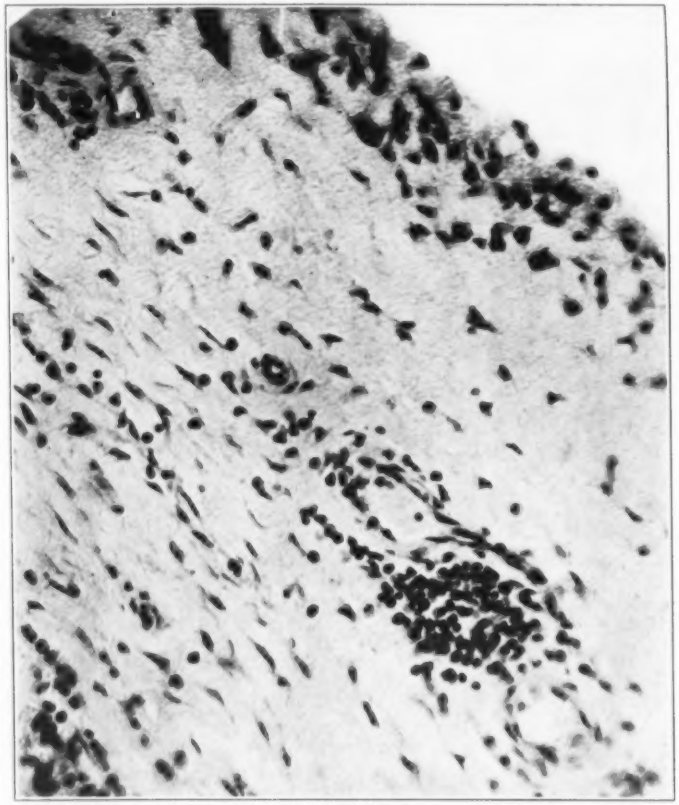

FIG. 5

Synovial membrane with oedematous subsynovial tissue and small nodules of round cells. (8 millimeters' objective.)

Microscopic: Epithelial cells and leucocytes, with occasional few red blood cells and hyaline casts.

Urine culture: Catheterized specimen—negative.

Blood chemistry: Urea nitrogen 9.45 milligrams per 100 cubic centimeters of blood; non-protein nitrogen 29.58 milligrams; uric acid 2.78 milligrams; creatinin 1.39 milligrams.

Blood count: Hemoglobin 83 per cent.; red blood cells 4,650,000; white blood cells 6,900.

Basal metabolism: Plus 14.

X-ray Examination

Spine: The lumbar spine showed very definite arthritic changes. In the lateral view the articulating surfaces were roughened and irregular, the lime salts were increased, and the anterior edges of the vertebrae were marked by new bone production.

Knees: In the knees, the intra-articular spaces were quite narrowed; the crucial spines were irregular. The latter were hypertrophied, increased in length, and ended in sharp apices. Both the condyles and tuberosities were squared and sharpened at the lateral margins, and nearly apposed one another. Throughout the bone ends the increase in lime salts was notable. Lateral views accentuated the uneven articulating surfaces and the new bone production.

Pyelogram after cystoscopy: not abnormal.

Course

After entering the hospital the included examinations were made and the patient was kept in bed, with hot fomentations on the knees and traction on each leg. Four days after admission, the tonsils were removed. Three weeks later we could see little change in the local conditions, but did have an opportunity to witness several cycles of periodic swelling in the two knees.

A synovectomy was then performed on the right knee. The operation and convalescence were uneventful. The wound healed promptly, and massage, with passive motion, was instituted within ten days. Following this operation there was a prompt remission of the periodic swelling in both knees. There was a marked effusion in the knee after the operation; but as time passed this gradually subsided, leaving a joint perceptibly improved, both as regards function and symptoms. Up to the present time, a period of two years, there has been no recurrence of the periodic effusion. However, about two months after the synovectomy the patient called attention to vague discomfort in the left knee, and nine days later the knee became swollen and painful. It was evident that the periodicity had again returned in full force to this joint. Two and one-half months after the right knee was operated upon a synovectomy was done on the left knee. The postoperative effusion was more slowly absorbed than in the first instance, but the joint returned to a more normal course. The improvement noted in the right knee failed to appear with the same rapidity, but there was a prompt remission of the periodic swelling which has not reappeared up to the present.

Gross Pathology

Upon incising the thickened capsule of the right knee joint, purplish red clusters of synovial membrane popped into the wound. A careful dissection was made, removing in all about two handfuls of the synovial tissue which covered and obscured any view of the joint. The hypertrophied fringes extended well up and completely filled the quadriceps pouch. The crucial ligaments were covered and a mass was reflected about the infrapatellar fat pad. Scattered through the synovial fringes were large globules, about one inch square and perhaps one-quarter inch in thickness. The globules were of a pale cream color and in most instances attached to the membrane by a very fine pedicle; they were probably masses of fibrin.

The cartilage of the tibia and condyles had lost the natural luster, was quite thin, and contained irregularly roughened areas of a distinctly yellow cast. At the extreme marginal attachments the cartilage was definitely eroded by a pannus. This was particu-

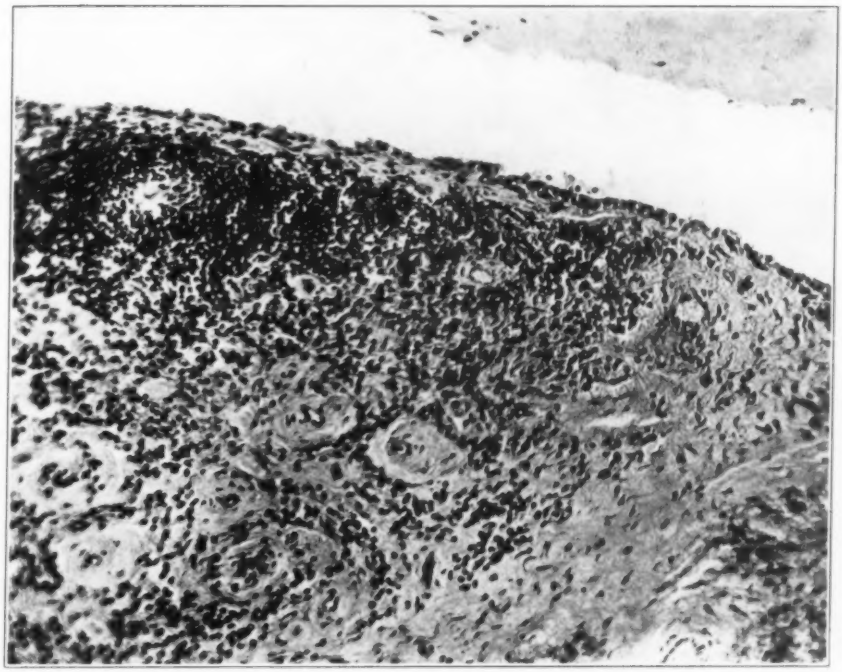

FIG. 6

Synovial membrane with large nodules of round cells and several sclerotic vessels. At the upper right corner there is a bit of fibrin, which is adherent to a neighboring villus. (16 millimeters' objective.)

larly well shown in the intercondyloid notch, where the most serious invasion and erosion had taken place. The synovial fluid was small in amount and distinctly yellowish in color.

The left knee presented practically the same picture. However, the amount of hypertrophied synovial tissue was much less, though even here considerable erosion of bone and cartilage had taken place along the joint margin.

Gross Examination

"Specimen consists of four large and several small fragments of soft tissue. . For the most part the consistency is that of fat, with relatively little fibrous tissue. In some places the synovial surface is comparatively smooth, while in others there are a few medium-sized villi. Some of these villi are branched, others are pedunculated. In some areas the synovial membrane is moderately thickened."

Microscopic Examination *

"The synovial cells are moderately increased in number and are from two to four times as large as normal. There are from three to eight layers of these cells, and in some areas the large, elongated, synovial cells are arranged with the long axis perpendicular to the joint surface, with one or more processes projecting into the joint cavity. Many of these large cells contain from two to four nuclei. The subsynovial layer is unusual in that it is markedly oedematous and is moderately infiltrated with mononuclear cells. Beneath this oedematous layer there is in places a thick layer of adipose tissue. In

* The authors are indebted to J. Albert Key, M.D., of St. Louis, for the microscopic analysis and the photomicrographs.

some places the oedematous tissue contains a thin coagulum which is probably fibrin. In other places the oedematous subsynovial layer rests upon a layer of fibrous tissue which is about normal in thickness and consistency. The infiltration of the subsynovial layer with mononuclear cells is in places quite marked and takes the form of collections of small round cells three or four hundred microns in diameter. As a rule the infiltrating cells are medium-sized round cells of the type usually described as monocytes or endothelial leucocytes. There are also a few phagocytic cells which are loaded with broken-down red cells (clasmatocytes). In some sections these are very numerous. Some of the monocytes contain several nuclei and resemble foreign-body giant cells. Some sections contain hyalinized areas which are sparsely populated with fibroblasts, small round cells, and extravasated red blood cells.

"A hyaline layer may replace the subsynovial oedematous layer. This hyaline layer is apparently fibrin which has become adherent to the synovial surface and invaded by connective-tissue cells and blood vessels. The villi are of various sizes and shapes, ranging from small sessile villi to large pedunculated villi with extensive branching. In structure the villi do not differ materially from that of the synovial surface described above.

"The vascularity of the tissue varies greatly in different sections. The hyalinized and oedematous areas contain relatively few blood vessels, while many of the villi are richly supplied. The walls of many of the smaller blood vessels are thickened and many of them are surrounded by a hyalinized zone. On the other hand, some of the large villi contain large, thin-walled, vascular spaces.

"The tissue contains relatively few polymorphonuclear leucocytes. The hypertrophied synovial cells do not contain any visible vacuoles or granules. No large lymph spaces were seen in the section."

Diagnosis: Chronic arthritis.

Discussion: The specimens from the two knee joints present practically the same picture. The pathological changes resemble those found in chronic atrophic (proliferative) arthritis. However, the extensive hyalinization and the large amount of oedema present in these joints would be unusual findings in the ordinary atrophic arthritis.

COMMENT

It is nearly five years since the synovectomies were performed, and up to date there has been no recurrence of the periodic effusion. In a recent personal communication the patient states that at the present time he is completely bed-ridden by the progressive arthritis, which has involved the spine and hip joints to a severe degree.

This case obviously falls within the group reported as having a close relationship to chronic arthritis. The remission, which occurred following pneumonia and again when an autogenous vaccine was given, is of interest. Throughout the literature it has been noted that pregnancies have provided periods of remission. In a personal communication (Shands and Leadbetter) was given the report of a case of intermittent hydrarthrosis which was completely interrupted by pregnancy. Shands also described a case in which streptococcus viridans was cultured from fluid aspirated from the affected joint. When an autogenous vaccine was given, the condition was much improved. This patient also had an associated arthritis.

The authors feel that this process falls within the scope of an allergic reaction, and the case history reported seems to bear out this assumption; however, no adequate explanation of the periodicity is at hand.

BIBLIOGRAPHY

1. Moore, C. H.: Periodical Inflammation of the Knee-Joint. Lancet, I, 485, 1864.
2. Brackett, E. G., and Cotton, F. J.: Intermittent Hydrops. Boston Med. and Surg. J., CXLV, 484, 1901.
3. Marsh, H.: Intermittent Hydrops of the Joints: and the Influence of Growth on Deformities. Lancet, I, 1549, 1904.
   Intermittent Hydrops of the Joints. Lancet, I, 1069, 1905.
4. Hildebrand, O.: Die Entstehung des Gelenkhydrops und Seine Behandlung. Arch. f. Klin. Chir., LXXXI, 412, 1906.
5. Bierring, W. L.: Intermittent Hydrarthrosis. J. Am. Med. Assn., LXXVII, 785, 1921.
6. Schlesinger, H.: Hydrops Hypostrophos und Hydrops Articulorum Intermittens. Mitt. a. d. Grenzgreb. d. Med. u. Chir., V, 441, 1899.
   Ueber den Hydrops Articulorum Intermittens und Seine Familiäre Form. Wiener Klin. Wchnschr., XXXIX, 68, 1926. Abstracted in J. Am. Med. Assn., LXXXVI, 728, 1926.
7. Miller, J. L., and Lewin, P.: Evidence of the Anaphylactic Character of Intermittent Hydrarthrosis. J. Am. Med. Assn., LXXXII, 1177, 1924.
8. Shands, A. R., and Leadbetter, G. W.: Personal Communication.
9. Freiberg, J. A.: Allergy as a Factor in the Production of Proliferative Arthritis. Arch. Surg., XVIII, 645, 1929.

FRACTURE OF THE PATELLA

A New Operation

BY FRANK R. OBER, M.D., BOSTON, MASSACHUSETTS

During the past decade the use of living sutures in cases of fractured patellae has become increasingly popular among surgeons. Strips of fascia lata or tendons are used for this purpose. When such strips are used, two incisions are necessary,—one to expose the patella, and one to expose the structures from which the suture material is to be obtained. In the operation described below, only one incision is necessary.

The incision is started four or five inches above the patella in the mid-line of the thigh and, as it approaches the patella, is swung medially to it, curving backward to the ligamentum patellae. The tendon of the quadriceps extensor, the aponeurosis of the patella, and the upper third of the ligamentum patellae are exposed. From the quadriceps tendon, which is very thick, there is split off transversely from above downward to the superior border of the patella a four-inch flap, the lower end of which is not divided. This flap is now split longitudinally, giving two strong strands of tendon about one-quarter of an inch wide. The patella is next

FIG. 1

Skin incision.

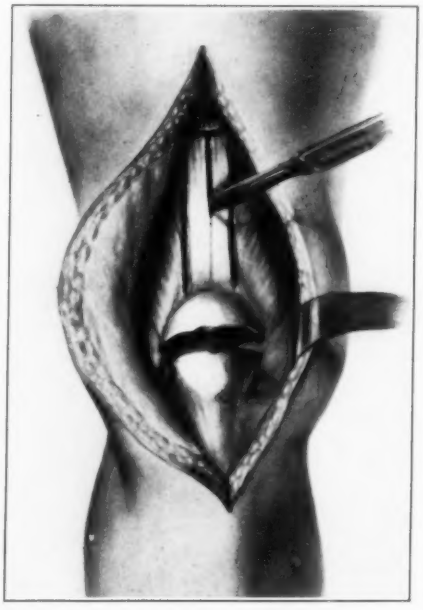

FIG. 2

Quadriceps tendon exposed, showing strips being dissected off anterior half of the tendon.

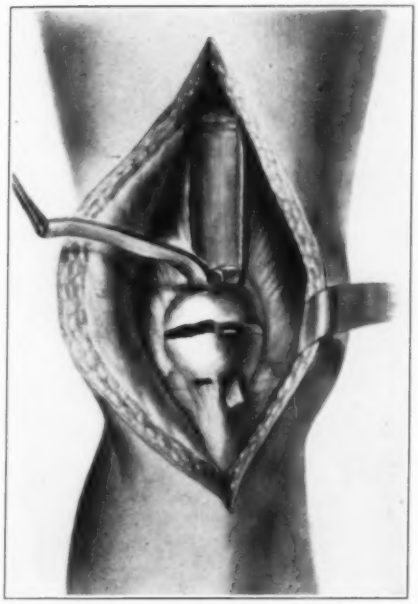

FIG. 3

Showing free strips of tendon left intact at lower ends, longitudinal drill holes in the patella and one tendon strip passed through drill hole.

FIG. 4

Showing two tendon strips drawn through the drill holes and sutured to each other and also to the ligamentum patellae.

drilled from above downward with a quarter-inch drill medial and lateral to each strand. A tendon strip is now passed through each drill hole. The protruding ends are sutured to each other and to the scarified ligamentum patellae.

REPORT OF CASE

G. W. C., aged sixty-two, Rec. 15741. July 7, 1930.

On June 22, 1930, this patient, while riding in an automobile, was severely injured in a head-on collision. He sustained a transverse fracture of the left patella, a severe cut of his lower lip, and a large scalp wound above the left ear. The patient was taken to the

FIG. 5

Knee voluntarily extended.

FIG. 6

Knee flexed.

FIG. 7

Lateral x-ray. Shows solid union. Patella enlarged. Exostosis at upper margin does not interfere with function.

Norman Cross Hospital in Three Rivers, Quebec, where he stayed until July 5, when he was transported to Boston.

The operation described above was performed under spinal anaesthesia. On exposing the patella, a transverse fracture at the junction of the lower and middle thirds was seen. The fragments were separated about three-quarters of an inch, and the lower fragment was rotated anteriorly at its superior aspect. The knee joint was filled with organized blood clot and serum. The joint was slowly irrigated with normal salt solution, washing out all detritus.

The patella was united as described in the text; the torn capsule was sutured with interrupted chromic catgut No. 0, and the subcutaneous structures with plain catgut No. 0. A plaster cast was applied from the toes to the groin.

September 29, 1930: The cast was removed, and there seemed to be solid union. Patient was allowed to walk on crutches.

October 10, 1930: Thirty degrees of free motion.

November 1, 1930: Back at work, is able to walk without support, and can climb stairs. No pain.

March 25, 1932: Can extend knee completely and can flex it to eighty-five degrees. Solid union. No disability.

"OSTEOPLASTIC CUNEIFORM OSTEOTOMY" IN THE TREATMENT OF ANKYLOSIS

Report of Two Cases

BY S. ORELL, M.D., STYRSÖ, SWEDEN

From Styrsö Coast Hospital, Gothenburg, Sweden

For the past few years I have been investigating the use of small bone grafts implanted in the wound of the tibia at the site from which is generally taken the piece of bone used at the so called Albee operation in the treatment of spondylitis. In so doing I have found that boiled autoplastic bone grafts, implanted subperiosteally into defects of the bone, usually behave similarly to fresh bone grafts implanted in similar places.

The results of these investigations have also been used in bone transplantations in practical surgery. The description of two cases treated by this method is presented herewith.

Case 1. K. J. P., woman, aged twenty. (J. Styrsö Coast Hospital, Nos. 4096–5054–6614.) Admitted to Styrsö Coast Hospital February 21, 1930.

Extract from case report: At the age of seven patient had tuberculosis of right knee. Was treated for this complaint at Styrsö Coast Hospital in 1919 with the result that on her discharge the gonitis was healed, with the knee in good position and a mobility of about seventy degrees. According to the patient's statement, after discharge the knee became gradually stiff and crooked. She was readmitted to Styrsö Coast Hospital for recurrence of trouble during 1923–1925, and was subsequently discharged in healed condition with ankylosis of knee in about thirty degrees of flexion.

She was again admitted to the hospital on February 21, 1930, with symptoms of appendicular abscess.

Condition on admission: General condition impaired. Temperature, thirty-nine degrees, centigrade. Nothing abnormal in the chest. Abdomen tense. A large tender swelling could be felt in the right side of the abdomen.

Ankylosis of right knee, quite free from tenderness and not swollen. The knee was in a position of about forty-five degrees of flexion and about thirty degrees of abduction with the thigh.

The muscles of the right leg were considerably atrophied. As a result of the flexion contracture there was marked functional shortening of the right lower extremity, causing the patient to limp considerably. By more exact measurement of thigh and leg, a true shortening of the extremity of three to four centimeters was evident.

Lateral roentgenogram of right knee showed complete ankylosis, bone structure of typical nature and without signs of tuberculous foci. The tuberculous lesion had healed perfectly. There was no swelling of the joint capsule, indicating no signs of tuberculous changes. The patella was lying in front of the femoral condyles, the femur forming an angle of flexion with the tibia of forty-five degrees.

After the appendicular abscess had been drained and the patient had recovered from her severe septic state, I began to ponder upon the best method to correct her right knee.

By a *simple cuneiform osteotomy* one could, it is true, obtain correction

of the flexion contracture, but at the same time would get a true shortening of the extremity.

Such a shortening could also be obtained by an *arc-shaped cuneiform osteotomy* according to Helferich, or by a *frontal osteotomy* by Schepelmann's method.

An *arc-shaped osteotomy* by Stracker's method would not, on the other hand, result in any shortening. This operation is carried out through a lateral curved incision. The bone is cut through by saw, by the aid of a specially made block, in such a way that a transverse, much curved cylindrical surface is obtained, the axis of which is at right angles to the long axis of the femur. Along this cut surface the bone fragments can then be rotated in relation to one another as in a joint, and the flexed position of the knee can be corrected.

Yet great difficulties are encountered in the practical execution of Stracker's operation. It is difficult to obtain a cut surface with the desired curved shape by sawing through the bone during an operation. It is naturally much easier to cut out plane surfaces by the saw and there is much greater prospect of obtaining the desired result.

I therefore carried out the operation in this case in a method similar to osteoplastic amputations, and which I would like to call "*osteoplastic cuneiform osteotomy*".

On a lateral roentgenogram, taken before the operation, I drew with straight lines the wedge—of an angle of about thirty-five to forty degrees—that would have to be removed in a simple cuneiform osteotomy.

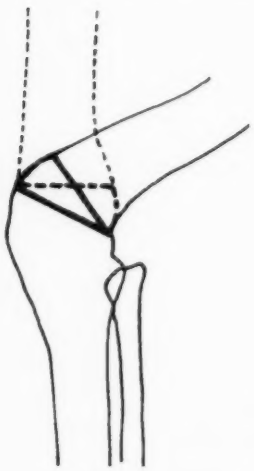

FIG. 1

The thick black contours indicate the cut surfaces of the wedge; the dotted contours indicate the corrected position. (From *Die Technik des Orthopädischen Eingriffs*, by Ph. J. Erlacher. Vienna, Julius Springer, 1928.)

If now, only the upper half of this wedge were removed—that is, a wedge with half the angle—and this wedge were rotated through 180 degrees and then replaced between the intact ends of the bone, one would gain in this way, as well as by Stracker's method, a straight extremity, with no loss of bone and no shortening and, moreover, the bone could be cut through in simple planes.

The operation was thus carried out in the following manner on May 9, 1930.

Osteoplastic cuneiform osteotomy:

Curved incision above patella from epicondyle to epicondyle. After cutting through the periosteum, this was detached upward and downward by a rasp. The bone was cut through by a hand-saw at the site of ankylosis so that, of the wedge that would have to be removed in a simple cuneiform osteotomy, only the upper half was removed. The wedge consisted of very brittle, spongious bone, with large cavities filled with fatty marrow and no traces of tuberculous foci. As the wedge during the operation happened to be touched by some unsterile object, it

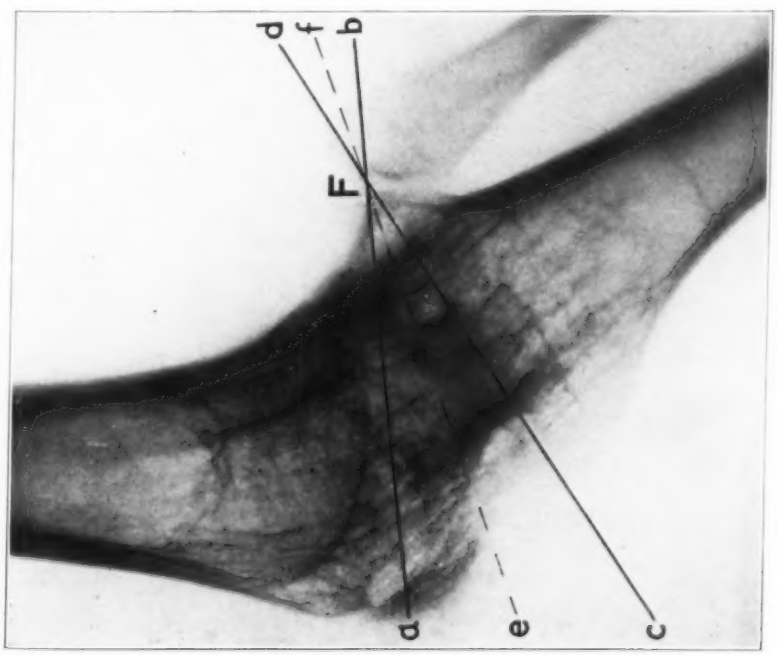

FIG. 2

The straight lines *ab* and *cd* indicate on the roentgenogram the wedge that would have been removed in an ordinary cuneiform osteotomy. Line *ef* represents the cut plane through which the angle of the wedge *aFc* is bisected into angles *aFe* and *eFc*.

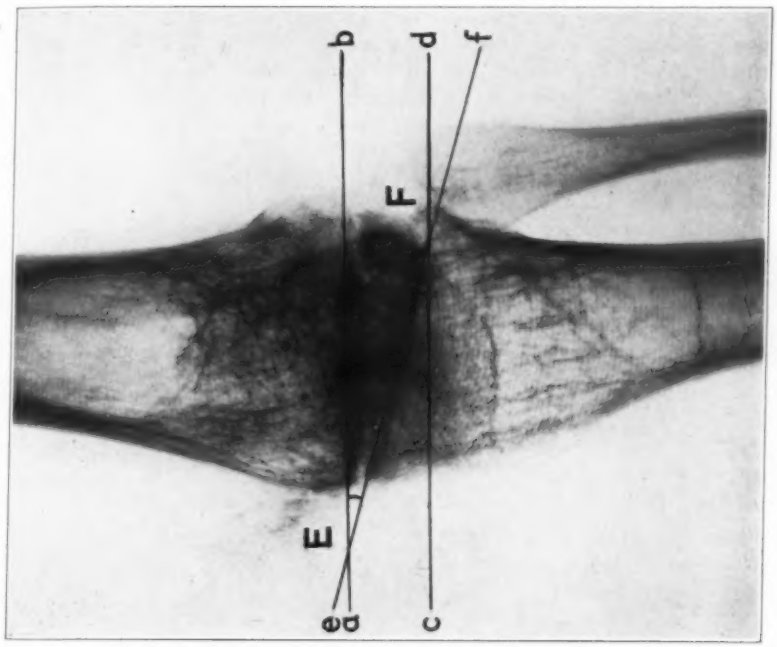

FIG. 3

Roentgenogram showing the position of the wedges after the operation. The upper wedge has at the operation been rotated through 180 degrees and the angles of the two wedges, *bEf* and *cFc*, have now such a position in relation to one another that the extremity has been straightened out.

was boiled for ten minutes in physiological sodium-chlorid solution. The wedge was rotated about 180 degrees and fitted in between the cut ends of the femur and tibia so that its highest part was placed posteriorly (Fig. 1). In so doing the tension of the soft parts was rather strong but was overcome without any greater difficulties. The position of the bones was thereby perfectly straightened. The wound was closed by primary suture and plaster bandages were applied around thigh, leg, and foot. The extremity was elevated to prevent too great postoperative bleeding. The operation was carried out under ether anaesthesia.*

The method of operation is best understood from the diagram (Fig. 1) and from the lateral roentgenograms, one taken before operation and another afterwards (Figs. 2 and 3), on which the wedges mentioned above will be found marked out by straight lines. On the roentgenogram after the operation, the bone graft will be seen, carefully fitted in between the femoral and tibial fragments.†

* For cutting out the wedge in osteoplastic cuneiform osteotomy I generally make use of a T bevel adjusted by roentgenogram before the operation; this has a convenient locking device which, after locking, prevents the blades from separating (Fig. *a*). Such bevels are adjusted after lateral and anteroposterior roentgenograms have been taken and are locked, after which they, together with the other instruments, are sterilized before operation. For this reason they are made of nickel-plated steel.

If, for the same purpose, one wishes to use a graduated, finer, and more expensive tool, then a Universal bevel protractor (Fig. *b*) may be used.

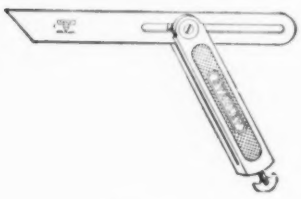

FIG. *a*

T bevel. (*Courtesy of The Stanley Rule & Level Plant, New Britain, Conn.*)

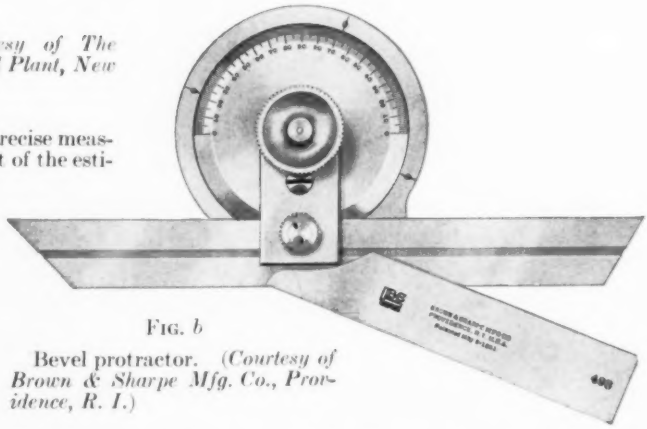

FIG. *b*

Bevel protractor. (*Courtesy of Brown & Sharpe Mfg. Co., Providence, R. I.*)

Should a more precise measurement of the height of the estimated wedge be desired, a Vernier caliper or a Fay spring divider (Fig. *c*) may be used with advantage; this is also adjusted after roentgenograms have been taken and is sterilized before operation.

FIG. *c*

Fay spring divider. (*Courtesy of The L. S. Starrett Co., Athol, Mass.*)

FIG. *d*

Pocket scriber.

If during the operation it is wished to mark out on the bone the planes to be cut through by the saw, this is done by scratching with a pocket scriber (Fig. *d*).

It should be pointed out here that these exceedingly cleverly devised and tried tools, which are employed by craftsmen in skilled work with wood and iron, and of which a large assortment is made in standard models by the great tool manufacturing works, should be called into aid in our surgical work.

† Application of Euclid, I, Proposition XXVII,—If a straight line meeting two other straight lines in the same plane makes a pair of alternate angles equal, then these two straight lines are parallel.

The general condition was satisfactory after the operation, the wound healing by first intention. There were no motor disturbances in the leg.

During the ninth week after the operation the patient was allowed to put weight on her legs with her right leg in plaster. There was no pain in the knee and gradually she became able to walk quite unhampered and without any inconvenience from the knee.

September 14: Patient was discharged four months after the operation. General condition was good, with good position of the knee.

November 31: The knee felt quite firm, as in bone ankylosis.

December 2: Leather support was applied.

On examination in March and August 1931, the knee was still in a good position. The iliac-spine-malleolar line on the right side is now only one and one-half to two centimeters shorter than on the left side. After the operation the extremity would thus seem to have become longer, probably as a result of increased function or strain after correction of the flexed position.

REPORT ON THE ROENTGEN EXAMINATIONS

Anteroposterior and lateral roentgenograms were taken 14, 61, 118, 304, 350, 378, 406, and 465 days after operation.

Roentgenogram 14 days after operation: The structure of the lateral part of the graft is very thin and does not reach the borders of the condyles. The medial part of the graft is also thin and almost devoid of structure. No periosteal or endosteal reaction.

FIG. 4

Case 1. Anteroposterior roentgenogram 465 days after the operation.

FIG. 5

Case 1. Lateral roentgenogram 465 days after the operation.

Roentgenograms 61 days after operation: Graft partly sclerosed. Still no periosteal or endosteal reaction.

Roentgenograms 118 days after operation: The graft appears to be somewhat lower than before, with small absorptive foci.

Roentgenograms 304 days after operation: Graft much more sclerotic than before. Still no periosteal reaction but an unquestioned endosteal reaction.

Roentgenograms 350 days after operation: Increasing endosteal reaction; now there is also definite structure with well marked bone laminae.

Roentgenograms 406 and 465 days after operation: The new bone formation now appears with more distinct structure than before. In addition distinct absorptive foci can be seen in the posterior higher parts of the graft (Figs. 4 and 5).

If the lateral roentgenograms 61 and 465 days after the operation are compared, the grafted wedge on the latter appears to be lower than on the former. It is clear from measurement, however, that the angle between the femur and the tibia is the same and that the condylar regions of the femur and the tibia are of the same height.

Case 2. S. E. K., male, aged fifteen. (J. Styrsö Coast Hospital, No. 6677.) Admitted to Styrsö Coast Hospital on June 28, 1930.

Extract from case report: Since 1925 patient had been suffering from left-sided tuberculous coxitis for which he had been treated in the hospital since 1926.

On admission to Styrsö Coast Hospital on June 28, 1930, the coxitis was perfectly healed, both on clinical and roentgenological evidence, with bony ankylosis of the hip joint, the femur in about five degrees of abduction and about thirty degrees of flexion in relation to the pelvis, and with about five centimeters of functional shortening of the left leg. Patient was admitted to the hospital for correction of the faulty position in the hip joint.

By measurements it was ascertained that for equalizing the length of the legs one needed an increase in the abduction of the hip of about thirty degrees.

August 14, 1930: Operation: *Subtrochanteric osteoplastic cuneiform osteotomy with replantation of wedge.* With a Gilgi saw a wedge was cut out of the left femur below the trochanter, so that each cut plane formed an angle of fifteen degrees with the transverse plane of the femur. The angle of the wedge was thus thirty degrees and its apex situated medially. The wedge was then boiled in physiological sodium-chlorid solution for at least ten minutes, and afterwards replaced after rotation through 180 degrees in its former position, the apex of the wedge thus pointing laterally. The apex of the wedge was fixed to the intact femoral fragments by strong catgut. By the aid of the extension arms of the operating table the extremity was so adjusted that the femoral fragments formed an abduction angle with one another of thirty degrees, allowing the wedge, as evidenced by roentgenogram, to fit in well between the fragments. The wound was closed and a circular plaster applied around ankle, knee, and hip.

Stitches were removed two weeks after the operation; the wound had healed. On September 12 a great amount of clear brown fluid escaped from the wound at one place as if originating from a hematoma.

September 17: Wound again closed and dry.

November 3: Three months after operation; patient able to dress.

April 10: Leather support recommended. Discharged well in July 1931.

REPORT ON THE ROENTGEN EXAMINATION

Anteroposterior views were taken 27, 56, 84, 113, 151, 193, 256, and 299 days after the operation.

Roentgenogram 27 days after operation (in plaster): The bone graft fits well between the fragments of the femur. The angle between the femoral fragments is thirty degrees. Periosteal reaction is beginning.

Roentgenogram 56 days after operation (in plaster): Absorption is beginning in the graft and in the adjacent bone ends. The periosteal reaction is more prominent than before.

FIG. 6

Case 2. Anteroposterior roentgenogram 27 days after the operation.

FIG. 7

Case 2. Anteroposterior roentgenogram 299 days after the operation.

Roentgenograms 84, 113, and 151 days after operation (in plaster): Increased tendency to absorption with fragmentation of the graft and about one centimeter of the adjacent ends of the femoral fragments. No collapse of the graft or of the ends of the femoral fragments can be seen, however. At the same time the new bone, periosteally formed, is becoming more and more dense.

Roentgenograms 193, 256, and 299 days after operation: The new periosteal bone is becoming more and more prominent. There is also now an obvious endosteal reaction. The graft can scarcely be discerned any longer. There is no demonstrable shortening of the leg.

The graft appears to have become disintegrated and absorbed as have also the nearest portions of the femoral fragments, while new bone is being formed by the tissues surrounding the graft. The compact bone and marrow of the femoral fragments do not seem to undergo any changes except in their very outermost ends. The new bone seems to arise in those soft parts close to the bone where injury has taken place. The newly formed bone assumes a shape and dimensions, in all probability occasioned by the altered mechanical conditions, resulting from the osteotomy and transplantation.

A characteristic feature of both these cases, and one of particular interest, is that the cut-out and replaced bone wedge could be precisely estimated beforehand, both regarding size and shape, and then cut out accordingly and exactly at the operation and, further, that the bone wedge, although it was boiled for ten minutes in normal saline, became united with the neighboring bone and clinically fulfilled in a perfect manner the desired function.

By osteoplastic cuneiform osteotomy we aim at a reshaping of the bone by resection of a wedge-shaped segment, carefully estimated beforehand, and its replacement or replantation in a different position. The bony wedge will then by its shape and adaptation contribute to the maintenance of the altered shape of the bone after operation. Thanks to the wedge fitting in well between the bone fragments and all cut surfaces being simple planes, no spaces arise between these surfaces; wherefore, the conditions for bony union are rendered as favorable as possible.

In the above described cases of osteoplastic cuneiform osteotomy it is, however, not only the method of operation in itself that is of interest, but also the question as to how the resected and replanted grafts unite after the operation.

My two cases of osteoplastic cuneiform osteotomy, which were carried out under strict observance of the general rules of surgery and asepticism, show a union of the boiled pieces of bone which on the whole tallies well with the results gained by Epstein and Kasakevič as found on examination of the fresh bone segments after experiments with Springer's operation on guinea-pigs.[7]

This is true in the first place of the clinical functional result. My patients began to walk with local support after having been in bed for from two to four months. Twelve months or more after the operation there has still been no clinical nor roentgenological signs of collapse of the bone wedges nor any evidence of their having been unable to cope with the mechanical strain to which they have been exposed during walking. The union between adjacent fragments has been good.

With regard to the dominating part that the periosteum is supposed to play in the regeneration of bone, the two cases here described behaved differently. In Case 2 the roentgenograms show, as after Springer's operation, how new calcified material is being formed in large quantities below the periosteum surrounding the wedge and ends of the bone fragments. In Case 1, however, one is unable to find that the periosteum is of any importance in the osseous regeneration. At the outer borders of the wedge, as in those parts lying close to the periosteum, no new bone formation can be seen but instead a depression of the bony outline. New bone formation, apparent on the roentgenograms as a new formation of bony structure, is only discerned within the substance of the bone wedge, particularly in the lowest parts of the wedge.

As in both my cases the cells of the bone wedge must be considered dead on account of the boiling, the new bone formation must have taken place from the cells of the surrounding living tissues. Which tissues or cells have thus created the new bone can of course only be determined by histological examination.

The roentgen examination in my second case, however, goes to show—like Epstein's and Kasakevič's investigations of guinea-pigs after Springer's operation—that in bone transplantation in the diaphysis the regeneration of bone is of periosteal type; while the roentgen examination in my first case, on the other hand, indicates that in bone transplantation in the epiphysis the bone regeneration is of endosteal type. These two types of bone regeneration remind one of new bone formation of the cartilaginous skeleton during the embryonic stage of development,—that is, of the perichondral and enchondral new bone formation in diaphyses and epiphyses, respectively.

The signs of necrosis and resorption of the bone substance in the wedges or segments and in the ends of the solid bone fragments are obvious in both my cases. Yet the necrotic processes and resorption of the bone do not seem as yet to have resulted in any diminished stability of the bone wedges, or, at any rate, the necrotic parts together with the new bone have exhibited such a mechanical stability as to enable the bone wedges to fulfil their function. The necrotic parts of the bone in the central parts of the wedges remain for a rather long time and will probably gradually be replaced by new bone from the cells of the invading tissues, or possibly become partly absorbed and replaced by connective tissue (Phemister)[24].

A pseudarthrosis may, of course, occur in such cases where the surgical fixation after the operation has been unsatisfactory.

As mentioned in the early part of this paper, I had previously found that small pieces of boiled bone implanted subperiosteally in bone defects behave practically in the same way as small fresh bone fragments in a similar place.

Judging from Epstein's and Kasakevič's writings and according to my own two cases described above, relatively large bits of boiled bone implanted as wedges between cut bone ends also would seem to behave on

the whole in the same way as large pieces of fresh bone implanted as segments in a similar place. The slow resorption of the necrotic parts in fresh and boiled bone and equally slow substitution of new bone is probably due to the difficulties encountered by the surrounding living tissues in invading the interior of the bone sufficiently rapidly, by their newly formed cells. It has thus happened that after homoplastic transplantation of fresh bone grafts of larger size, a shorter or longer time after the transplantation, these have collapsed and been unable to withstand the mechanical strain involved (Lexer and others).

It is clear, then, that when bone is to be transplanted, it should undergo some preliminary preparation in order to facilitate a speedy invasion of tissue juices and cells into the canal systems. This preparation should aim at removing connective tissue and fat as completely as possible from the canals to enable the tissue juices and cells to come in direct and intimate contact with the bone substance of the walls of the canals. In addition, a removal of nitrogenous substances in homoplastic and heteroplastic transplantation of bone is likely to have a more favorable effect upon the bone regeneration than is generally the case otherwise. I have employed such a method of preparation in several cases, which method will be described in a future publication.

The x-rays have been examined and the roentgen reports revised in conference with Dr. Nils Westermark, Physician-in-charge of the Roentgen Department of S:t Göran's Hospital, Stockholm.

SUMMARY

"Osteoplastic cuneiform osteotomy" in ankylosis of the knee joint or hip joint with a position of flexion or adduction has from an operative point of view—besides the maintaining of the true length of the extremity—the technical advantage that the osteoplastic osteotomy, because of the osteotomies being laid in simple planes, can be carried out exactly as estimated beforehand. In consideration of this, the method would seem likely to be of use in other cases of similar nature and perhaps also be useful in plastic treatment of other bone deformities.

Osseous segments can be resected, boiled, and again implanted with a good prospect of union and function.

The union of boiled autoplastic bone segments in bone defects would seem to proceed clinically and roentgenologically in the same manner as the union of fresh autoplastic bone segments. The boiled segments seem, like fresh ones, to be mainly replaced by new bone tissue, while the old bone tissue undergoes necrosis and becomes resorbed. Smaller portions of necrotic bone tissue in the segments are for a long time evident in the roentgenogram. The boiled bone segments seem to be able to fulfil the mechanical function aimed at by the plastic operation.

After resection and reimplantation of segments in the diaphysis, periosteal bone regeneration is the dominating one; after such operations in the epiphysis, endosteal regeneration predominates.

A preliminary preparation of the bone graft for the purpose of removing, as completely as possible, connective tissue and fat from the bony canals would probably, in a grafting operation, hasten and render more complete the union and reconstruction of the graft. The author has worked out such a preliminary therapeutic method and is at present subjecting it to surgical tests.

Osteoplastic (autoplastic, homoplastic, heteroplastic) cuneiform osteotomy, carried out according to standard methods, is a relatively simple, practical, and efficacious method for clinically testing and evaluating bone transplantation generally as an aid to surgical therapy.

BIBLIOGRAPHY

1. Báron, A.: Über die Bedeutung der Spongiosa bei der Knochentransplantation. Zentralbl. f. Chir., LIII, 2332, 1926.
2. Barth, A.: Ueber Osteoplastik. Arch. f. Klin. Chir., LXXXVI, 859, 1908.
3. Bertini, G.: La Vascolarizzazione negli Innesti Ossei Autoplastici. Ricerche Sperimentali. Arch. Ital. di Chir., XVI, 105, 1926.
4. Brandt, G.: Kreuzförmige Osteotomie bei Rachitischen Unterschenkelverkrümmungen. Zentralbl. f. Chir., LII, 79, 1925.
5. Christophe, L.: Recherches sur les Greffes Osseuses. Presse Méd., XXIX, 204, 1921.
6. Drevermann, P.: Die Einfache Subperiostale Knochenresektion zur Behandlung Rachitischer Verkrümmungen im Kindesalter. Zentralbl. f. Chir., LI, 331, 1924.
7. Epstein, G. und Kasakevič, J.: Das Schicksal der Knochensegmente nach der Springerschen Operation. Bruns' Beitr. z. Klin. Chir., CXLIX, 594, 1930.
8. Erlacher, Ph. J.: Die Technik des Orthopädischen Eingriffs. Vienna, Julius Springer, 1928.
9. Haas, S. L.: Function in Relation to Transplantation of Bone. Arch. Surg., III, 425, 1921.
10. Hackenbroch, M.: Zur Operativen Korrektur Schwerer Rachitischer Unterschenkelverkrümmungen. Zentralbl. f. Chir., LI, 333, 1924.
11. Helferich: Ein Neues Verfahren zur Operation der Winkeligen Kniegelenksankylose. Verhandl. d. Deutsch. Gesellsch. f. Chir., XIX, 383, 1890.
12. Hoffmann, V.: Die Autoplastischen Knochentransplantationen vom Standpunkt der Biologie und Architektonik. Arch. f. Klin. Chir., CXXXV, 413, 1925.
13. Kirschner, M.: Der Ausgleich Knöcherner Deformitäten. Arch. f. Klin. Chir., CXXVI, 523, 1923.
14. Koch, H.: Röhrenknochendefektersatz durch Freie Autoplastische Knochentransplantation. Beitr. z. Klin. Chir., CXXXIX, 635, 1927
15. Krukenberg, H.: Ueber ein Neues Operationsverfahren zur Behandlung Schwerer Fälle von Genu Valgum. Ztschr. f. Orthop. Chir., XI, 234, 1903.
16. Lickteig, E.: La Reconstitution de la Machoire Inférieure parles Différentes Autogreffes et Hétérogreffes Osseuses. L'Odontologie, LIX, 379, 1921.
17. Loeffler, F.: Zur Operativen Behandlung Hochgradiger Rachitischer Verkrümmungen. Deutsche Med. Wchnschr., XLVI, 1274, 1920.
18. Matti, H.: Ueber Modellierende Osteotomie und Spongiosatransplantation. Schweizerische Med. Wchnschr., X, 1254, 1929.
19. Mauclaire, Pl.: Chirurgie Génerale et Chirurgie Orthopédique des Membres. *In* Nouveau Traité de Chirurgie, XXXIII. Paris, J. B. Baillière et Fils, 1913.
20. Morestin, M. H.: Ankylose Vicieuse du Genou, en Antéflexion, Consécutive à une Résection Pratiquée dans l'Enfance. Correction de la Difformité par Excision d'un Fragment Osseux Cunéiforme et Greffe Immédiate du Même Fragment Replacé en Sens Inverse. Bull. et Mém. Soc. de Chir. de Paris, XXXVII, 1235, 1911.

21. MÜLLER, W.: Die Wirkung Verminderter Zirkulation auf das Knochengewebe. Arch. f. Klin. Chir., CXLII, 610, 1926.
22. ORELL, S.: Experimentalchirurgische Studie über Knochentransplantate und Ihre Anwendung in der Praktischen Chirurgie. Deutsche Ztschr. f. Chir., CCXXXII, 701, 1931.

Extremity Surgical Operating Table. Acta Chir. Scandinavica, LXVII, 618, 1930.
23. ORTH, O.: Operatives Vorgehen bei den Rachitischen Verkrümmungen. Zentralbl. f. Chir., I, 989, 1923.
24. PHEMISTER, D. B.: Repair of Bone in the Presence of Aseptic Necrosis Resulting from Fractures, Transplantations, and Vascular Obstruction. J. Bone and Joint Surg., XII, 769, Oct. 1930.

Aseptische Knochennekrose bei Frakturen, Transplantationen und Gefässverschlüssen. Ztschr. f. Orthop. Chir., LV, 161, 1930.
25. ROBINSON, W. H.: Cuneiform Osteotomy. A Method of Planning Dimensions of Wedge to be Removed. Am. J. Surg., XII, 546, 1931.
26. ROHDE, C.: Komminutivplastik der Tibia bei Schweren Rachitischen Deformitäten mit Pseudarthrose, nebst einigen Bemerkungen zur Knochenregeneration. Arch. f. Orthop. u. Unfall. Chir., XX, 281, 1922.
27. RUDOLF, A.: Die Segmentierung nach Springer am Oberschenkel. Zentralbl. f. Chir., LI, 1165, 1924.
28. SACCO, R.: Osteotomie Multiple nella Cura delle Gravi Arcuature Rachitiche della Tibia. Chir. d. Org. di Movimento, IX, 189, 1925.
29. SPIŠIČ, B.: Über eine Einfache Methode der Operativen Korrektur der Schweren Rachitischen Unterschenkelverkrümmungen. Zentralbl. f. Chir., LI, 661, 1924.
30. SPRINGER, C.: Operativer Ausgleich Hochgradiger Knochenverbiegungen durch Zersägung in Scheiben (Segmentierung). Verhandl. d. Deutsch. Orthop. Gesellsch., XV, 118, 1920.

Ueber die Segmentierung Hochgradiger Rachitischer Knochenverkrümmungen. Bruns' Beitr. z. Klin. Chir., CXXXII, 696, 1924.
31. STRAUSZ, H.: Über eine Einfache Methode der Operativen Korrektur der Schweren Rachitischen Unterschenkelverkrümmungen. Zentralbl. f. Chir., L, 1692, 1923.
32. STREISSLER, E.: Der Gegenwärtige Stand Unserer Klinischen Erfahrungen über die Transplantation Lebenden Menschlichen Knochens. Beitr. z. Klin. Chir., LXXI, 1, 1910–1911.
33. VOELCKER,: (Discussion) Ueber Pseudoarthrosenbehandlung auf Grund von 18 Operativ Geheilten Fällen. Münchener Med. Wchnschr., LXIV, 1307, 1917.
34. WERNDORFF, R.: Zur Paraartikulären Korrektur der Kniegelenksankylosen. Die Keilförmige Paraartikuläre Osteotomie mit Freier Autoplastik eines Knochenkeiles aus der Tibia in den Oberschenkeldefekt. Wiener Med. Wchnschr., LIX 1230, 1308, 1909.

AN OPERATION FOR RECONSTRUCTION OF THE INADEQUATE ACETABULUM *

BY J. DEWEY BISGARD, M.D., CHICAGO, ILLINOIS

The literal interpretation of the term, inadequate acetabulum, implies an inclusion of all dislocations resulting from inadequate retention properties of the acetabulum to the upward, anterior, or posterior thrust of the articulating femoral head. For the purposes of this presentation a loose interpretation has been placed upon the term, restricting its application to the acetabulum capable of retaining the head after reduction, and including a group of cases with no actual dislocation but with symptoms produced by slightly inadequate acetabular roofs. As will become obvious from the subsequent description, reposition of the head within the socket is a prerequisite to the application of the principle involved in the operation to be presented.

The illustrations, Figures 2 and 3, depict an inadequate acetabulum in a girl ten years of age, resulting from residual paralysis of anterior poliomyelitis. The onset of this illness occurred when the child was ten months of age and the residuum involved the right

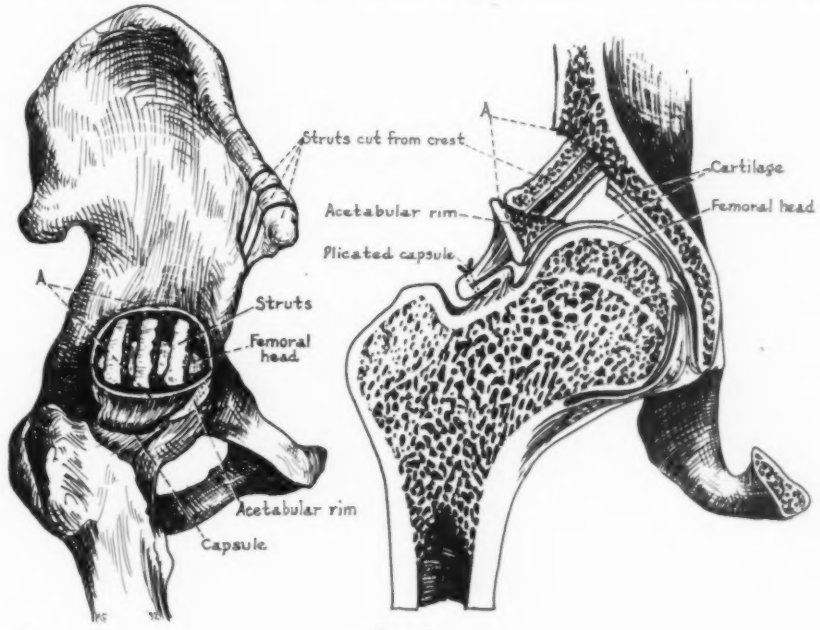

FIG. 1

A represents the distance that the acetabular rim is displaced laterally and downward to cup the femoral head. Its anterior and posterior pedicle attachments cause it to traverse an arc.

* From the Department of Surgery, Division of Orthopaedics, The University of Chicago.

FIG. 2

An inadequate acetabulum of the right hip joint resulting from residual paralysis of anterior poliomyelitis. The femoral head could be dislocated and reduced with little effort.

FIG. 3

Same patient. The femoral head dislocated upward by simply adducting the leg.

leg only. She learned to walk with the aid of a brace at the age of three. Since that time there has been a marked limp with an uncertain waddling gait which has become progressively worse. Upon examination there appeared a marked circumferential asymmetry of the two lower extremities and a length discrepancy of six centimeters. The neuromuscular systems were normal except for the right leg in which there was an almost complete loss below the knee and a partial loss (fifty to seventy-five per cent.) of the quadriceps, hamstring, adductor, tensor fascia lata, and gluteal muscle functions. The right femoral head dislocated upward with weight-bearing and with extreme passive adduction of the leg. There was a positive Trendelenberg and with the head dislocated, the trochanter presented well above Nélaton's line.

Four months after the operation (Fig. 4) the hip joint was completely stable with weight-bearing and could execute a full range of painless motion.

OPERATIVE TECHNIQUE

Through the usual Smith-Petersen approach, the periosteum is elevated from the outer table of the ilium until the upper half of the acetabular rim and the joint capsule are well exposed. If the femoral head is dislocated, it is (reduced) replaced within the acetabular cavity. This may necessitate opening of the capsule, release of an hour-glass constriction, severance of tight restricting bands (the Y ligament or iliopsoas) and the use of considerable traction and manipulation. The use of "skids" and other traumatizing instruments should be avoided.

FIG. 4

Same patient three months after the reconstruction operation illustrated in Fig. 1. Note the cupping relation of the displaced acetabular rim (*A*) to the femoral head. Note also the supporting struts (*S*).

Thus, with the head of the femur replaced, the acetabular rim is cut through into the joint with a thin-bladed osteotome over the proximal half of its circumference and pried laterally and downward in one piece as a pedicle attached at the extremities of the arc. Care is exercised to control the osteotome to avoid damage to the underlying femoral head. As the detached rim is displaced, it hinges as a bucket handle not only laterally, but downward in such a fashion as to cup the head. Struts are then cut from the crest of the ilium and interposed between the rim and the side of the ilium to hold the rim in its new position and to bridge the gap. If the capsule has been opened, it is now closed, and if redundant, plicated, and an anatomical restoration of the divided fascia and skin is effected. The hip is immobilized in moderate abduction in a plaster spica for a period of four to eight weeks.

With the removal of the cast, motion without weight-bearing and physiotherapy are carried out for four weeks. Early motion appears to promote new bone formation in the newly created shelf and to assure a wider range of motion.

This operation affords the advantages to be gained from a physiological and anatomical restoration which approaches the normal. It not only creates a roof which is continuous with the contour of the acetabulum, but also, to some extent, cups or circumvents the head of the femur. In consequence, maximum stability results. Likewise, since the joint capsule is carried down with the rim to which it is attached, it does not suffer impingement between the shelf and the femoral head, a condition existing after extracapsular shelf operations and considered by some observers to be a source of pain for a long time. Limitations to the use of the operation have been referred to.

THE TREATMENT OF JOINT LESIONS IN HEMOPHILIA BY MEANS OF WHOLE BLOOD FROM MENSTRUATING WOMEN

BY MAURICE A. BERNSTEIN, M.D., F.A.C.S., CHICAGO, ILLINOIS

The treatment of hemophilia has been as varied as its results. It has aimed to control hemorrhages by local applications of styptics, compression, absolute rest, fibrin ferment, and the various calcium preparations. Within the past few years blood transfusion has been found efficacious in controlling a single hemorrhage, but no lasting effects were noted from this method.

Minot and Lee [1] have made an observation that normal platelets added to hemophiliac plasma initiated prompt clotting. It is upon this principal that whole blood acts. The platelets found in normal blood liberate a ferment prothrombin, which combines with the calcium in the plasma and forms thrombin. The thrombin combines with the fibrinogen, and results in fibrin, an element necessary in blood clotting.

Grant,[2] in 1904, advised the use of ovarian extract in the belief that the ovaries had a protective influence against hemorrhage tendencies. He administered two and one-half grains of sheep's ovarian extract three times a day.

Gonzalez Alvarez,[3] in 1925, published an article on the treatment of hemophilia; the arguments and data presented by him sustain the view that hemophilia is the result of a congenital infection attacking the endothelial structures of blood vessels, and is usually of syphilitic origin. Women are protected, he thinks, by some hormone, and he suggests treatment of hemophilia with ovarian extract to simulate conditions in the female, besides supplying the lacking thrombin artificially.

Birch[4] more recently, advised this treatment, and speculated on the same theory, stating that the symptoms are held in obeyance in the presence of female sex organs. Two patients were treated by her during eleven and one-half months, and bleeding was controlled during that period. She states that the blood platelets in hemophiliacs have a greatly increased resistance both to hypotonic and hypertonic salt solution. When the resistance of hemophiliac platelets is overcome mechanically, the blood coagulates in normal time.

During the past years the author has treated cases of hemophilia according to accepted methods. The results were in accordance with those of others. The patients who come to bone surgeons are not the usual hemophiliacs who seek relief from repeated superficial hemorrhages; they are those seeking relief from joint affections.

Koenig [5] states that there are three forms of arthritis in hemophilia; (1) the simple hemarthrosis, with single repeated hemorrhages into the joints, with pain and limitation of motion; (2) the form associated with an inflammatory process in the joints, hemarthrosis and exudation into the

joint, and changes in the synovial membrane and capsular thickening, with organization of the exudate resulting in fibrosis, limitation of motion, swelling, discoloration of joint surface, fever, and often simulating tuberculosis; (3) the chronic inflammatory change in the joint with destruction of the articular cartilage, resembling arthritis deformans.

Two cases which are here described were boys who gave a history of bleeding since infancy. One boy had a tonsillectomy and when one tonsil was removed, the hemorrhage was uncontrollable, and the bleeding continued for six days, in spite of all measures to control it. Blood transfusion was resorted to for the control of this hemorrhage. Both cases were treated for years with all the known methods with no avail. Blood transfusion and whole blood intramuscularly were employed from time to time. The first boy bled from a needle puncture of the ear for two days. The coagulation and bleeding time of both cases was very much delayed. It was then decided to give these cases ovarian extract. This was done for a short time, but there was no change in the joint affections. Following this treatment, it was decided that, since ovarian extract is given on the basis that it adds an element contained within the female sex organs which has an effect upon the coagulation time of hemophiliacs, the blood of women during the period of the menstrual cycle might supply that ingredient in a more direct way. The first boy was therefore given ten cubic centimeters of whole blood intramuscularly every other day, taken from his mother during her menstrual period, and increased at the height of that cycle to fifteen cubic centimeters. The history and results follow:

Case 1. Boy, six years old, of good physical development, was brought for examination because of swelling and pain, and flexion contracture of the right knee and right elbow joints. The mother stated that the condition in the joints developed about a year before when she noticed discoloration, pain, and limitation of motion, and swelling of the right knee. The child was unable to walk on account of pain and contracture of the knee joint.

Past history: There were two children in the family, a girl twelve years of age, and the boy. Since birth the boy had shown signs of bleeding. Following his circumcision, he bled so extensively that two transfusions were resorted to for control of the hemorrhage. At one time he bit his tongue and an uncontrollable hemorrhage followed. The mother stated that whenever he injured himself there followed a blue discoloration in the skin. There were numerous blue discolorations over his legs, thighs, elbow, and lip.

Family history: Mother stated that she could not remember any male in her immediate family who had hemophilia.

Findings on examination: On examination the child proved to be a well developed boy for his age; the heart and lungs were normal; there were numerous discolorations on the extremities, showing recent and old bruises. A cut on the lower lip was oedematous and discolored. The right knee joint was flexed to about forty-five degrees; the muscles were spastic. There was considerable pain on movement. The knee was distended, discolored, and there was distinct limitation of motion. The right elbow joint was tender, painful on motion, and could not be fully extended. There were dark bluish discolorations on the extensor surface.

Blood examination: Aside from coagulation time, no studies of the boy's blood were made, prior to the institution of the present treatment. At the time of the first adminis-

FIG. 1

Roentgenogram taken November 20, 1930, shows lateral view of the right knee joint. The knee is considerably larger, and shows in the infrapatellar space an irregular dark shadow, surrounded by a density which fills the entire knee joint. This is due, perhaps, to an exudate of a hemorrhagic nature, which has assumed a fibrinous character. The patella is very small and irregular. Its surface is ragged and its center is decalcified, showing areas of vacuolization. The articular cartilage of the femur is streaked, ragged, irregular, and thin. The articular cartilage of the tibia is rim-shaped and narrow, surrounding a spongy-appearing, subchondral, cancellous bone end.

FIG. 2

Roentgenogram of knee joint of same patient, taken sixteen months later, showing joint of approximately normal contour. There is a slight difference in size of the two joints. The infrapatellar space is clear. The patella approaches the normal; it is slightly larger than in Fig. 1. There is considerable ossification of the ends of the bones. The articular cartilage is more uniform, but still shows a slight ragged appearance in its upper portion. The interarticular space is not diminished.

tration of his mother's blood, coagulation time was markedly delayed, taking hours for coagulation. Whenever blood was taken from the lobe of the ear for examination, bleeding would follow for a day thereafter, leaving a slight bluish discoloration around the needle puncture. When blood transfusion was given, the oozing from the vein and from the surrounding tissue continued for several days. The last blood transfusion was given in October, 1930. Following the blood transfusion, whole blood was given him intramuscularly from a male donor; there would result some remission of the symptoms, but at no time was there a complete absence of bleeding, nor were the joints at any time normal.

In August, 1931, it was decided to give the boy whole blood intramuscularly, taken from his mother during her menstrual period. Ten cubic centimeters of blood were injected in the gluteal region every other day during his mother's menstrual period, and

these injections have been continued every month to this date. After the first administration of fifty cubic centimeters of his mother's blood, no evidence of recent bruises could be noted. At the present writing, eleven months after the beginning of treatment, there is free motion of the joints, no pain, no swelling, and no discoloration. The platelet count is 400,000, and the coagulation time is from ten minutes to a half-hour. The coagulation time was taken after each injection of blood.

Case 2. Boy, fourteen years of age, who gave a history of repeated and frequent hemorrhages from the slightest injury or bruise. A tonsillectomy was performed on him some years ago, and after one tonsil was removed, the bleeding was so profuse that all palliative means failed to control the hemorrhage; a blood transfusion had to be done. Every manner of treatment was instituted to hasten coagulation, but all methods failed. On examination the tonsil bed looked hyperaemic and congested, with no signs of healing. There was a constant bloody serous discharge from the tonsil bed. Two-hundred and fifty cubic centimeters of blood was given the boy intravenously; and the hemorrhage promptly subsided, and the tonsil bed healed. He was started on ten cubic centimeters of his mother's blood intramuscularly, administered every other day during her menstrual period. Since the administration of his mother's blood he has been free of all evidence of bleeding.

Although it is evident that no definite conclusions can be drawn from two cases, and although the time may be too short to draw definite conclusions, yet this report is made to arouse interest in others who are confronted with the problem of treating hemophilia. The administration of whole blood intramuscularly is associated with no danger. The method can easily be carried out, giving the patient's mother's blood during her period of menstruation, and continuing for a few days thereafter. This is a method worth trying in combatting hemorrhage in hemophilia.

REFERENCES

1. Minot, G. R. and Lee, R. I.: The Blood Platelets in Hemophilia. Arch. Int. Med., XVIII, 474, 1916.
2. Grant, L.: On Haemophilia and Its Treatment. Lancet, II, 1279, 1904.
3. Gonzalez Alvarez, B. and Gonzalez Alvarez, M.: Hemophilia. Siglo Méd., LXXV, 7, 1925.
4. Birch, C. L.: Hemophilia. Proc. Soc. Exper. Biol. and Med., XXVIII, 752, 1931.
5. Koenig, W. J.: Quoted by Sir William Osler in The Principles and Practice of Medicine. Ed. 6. New York, D. Appleton, 1906.

INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)

BY MAURICE M. POMERANZ, M.D., NEW YORK, N. Y.

Hospital for Joint Diseases

The condition to be described may be defined as a non-traumatic, chronic progressive arthritis of the hip joint, characterized by intrapelvic protrusion of the acetabulum and head of the femur.

This lesion was recognized more than a century ago (1824) by Otto[1], and, although occurring infrequently, is of sufficient importance to orthopaedic surgery and obstetrics to justify a review of the subject. An indication of the timeliness of the latter was demonstrated recently by the report [42], of a case designated as "an unusual bilateral condition of the acetabulum", which apparently presented the typical features of an Otto pelvis. It should be stated at the outset that the association of Chrobak's name with that of Otto in connection with this disease is misleading, the former name having been attached by Eppinger [12], merely as a birthday tribute to Chrobak.

Diagnosed initially by Otto as "an abnormal gouty manifestation", this deformity has since been referred to by its reporters under the following diversified captions; Gurlt (quoted by Henschen [29]) referred to it as "a coxalgia with an acetabular fracture"; Eppinger (1903) suggested the term "*Coxarthrolisthesis-Becken*"; Kuliga (1905) referred to it as "an osteo-arthritis deformans"; Breus and Kolisko (1912), as "a peculiar destructive coxitis preferably localized in the acetabulum"; Schlagenhaufer (1908), as "gonorrhoeal arthritis"; Henschen (1909), as "caused by various processes of coxitis and neuropathy"; Schertlin (1911), as "a juvenile osteo-arthritis deformans"; Kienböck (1911) reported "an unusual deformity of the hip with protrusion of the acetabulum attributable to gonorrhoeal arthritis and tabetic arthropathy"; Chiari (1912) referred to this affection as "a tabetic coxarthritis"; Hertzler (1922), Pomeranz (1925), and Lewin (1925), as "an osteo-arthritic protrusion of the acetabulum"; Doub (1929), as "an intrapelvic protrusion of the acetabulum"; etc.

This disease was originally described by Otto[1] in 1824. As his description of a pelvis seen in an anatomical museum is the basis of all subsequent studies, the translation of it is presented as follows:

"This pelvis from an adult woman is, on the whole, fairly normal in size and build, its chief characteristic is the very deep insertion of both femoral heads in the acetabula; so that the floors of the latter protrude far into the pelvis and are at the same time imperfectly ankylosed.

"The right acetabulum protrudes into the pelvis like half an orange. It forms a round, smooth, fairly thick-walled, bony shell (all diameters of the base are two and three-quarters inches broad; from that point it protrudes into the pelvis one and one-half inches). At the crest—which approximately corresponds to the center of the acetabular

FIG. 1

Section illustrating the typical deformity. Reproduced from Breus and Kolisko by courtesy of the publisher. (*Die Pathologischen Beckenformen.* Wien, Franz Deuticke, III, 558, Fig. 150, 1912.)

fossa—is an irregular circular defect, measuring one and one-half inches, probably due to absorption, initially possibly closed by membrane, but now supplying communication between the acetabulum and abdominal cavity. The lower marginal portion of the ilium protrudes like a ball into the iliac notch, due to the extended acetabulum, so that its ordinary width of about two inches, as well as the distance between the tip of the os sacrum and the opposite iliac margin, is reduced to one inch. The acetabulum protrudes so far into the pelvis that it contains not only the head but also the normally long neck of the femur, and the upper acetabular margin articulates with the great trochanter. The entire inner aspect of the acetabulum is smooth, also the head of the femur; both are devoid of cartilaginous covering, and have the abraded and polished appearance of some gouty joints; only the portion of the femoral head opposite the acetabular defect is roughened and eroded by absorption. The acetabular margin is rough and uneven, slightly thickened, and so constricts the femoral head that the larger head cannot be removed from the cavity of the joint,—the transverse ligament of the acetabulum is ossified. (Since the roughened large trochanter grates on the roughened acetabular margin, and since the femoral neck is also somewhat angular and the small trochanter hits the sciatic tuberosity on backward flexion of the femur, the femur itself can be rotated only slightly forward and inward, but not outward and backward; thus the joint is so restricted that the abdomen and thighs form a right angle in the standing position.)

"The left hip joint behaves much like the right; its acetabulum does not protrude, however, quite so far into the pelvis, but only three-quarters of an inch; the neck of the femur also has not entirely dropped down into the acetabulum, yet, since the margin is thicker than in the right hip and more constricted, and since the neck of the femur shows several protuberances at the points of friction with the acetabular margin, movement is still more restricted; the arc described by excursion of the left knee anteroposteriorly is only seven inches long; the inner bilateral femoral tuberosities can be separated only for a distance of about four to five inches. In the left hip joint the transverse ligament is ossified and is three-quarters of an inch in breadth.

"The right sacro-iliac symphysis is ankylosed for about one inch, and because the right femoral head is deeply inserted, the lower end of the right femur appears to be shorter than the left by one inch.

"From the above described deformity and the whole appearance of the bone of this specimen, which is of interest to obstetricians, I believe the condition due to abnormal gout."

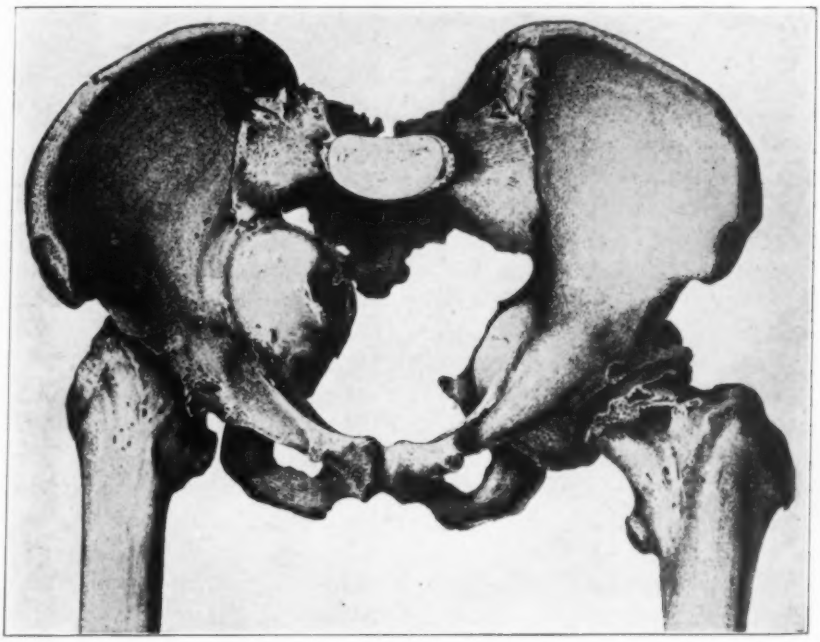

FIG. 2

Otto's original case. Reproduced from Breus and Kolisko by courtesy of the publisher. (*Die Pathologischen Beckenformen.* Wien, Franz Deuticke, III, 540, Fig. 142, 1912.)

The reproductions Figures 1 and 2 were obtained from Breus and Kolisko[27] and illustrate the typical deformity.

ETIOLOGY AND PATHOGENESIS

Differences of opinion regarding this disease have been occasioned chiefly: (1) by the wide range of etiological factors held to be responsible for the condition, and (2) by variations in the pathological findings reported. Based on the theory of various investigators that numerous transitional forms are possible, it appears that opinions might easily be influenced by the particular stage during which the process is noted; also by the fact that quantitative and individual fluctuations in the severity of the lesions must be reckoned with. Then, too, transitional forms may be missed at autopsy, although present, since the hip is not usually investigated *post mortem*.

A review of the literature in connection with the Otto pelvis points to an overwhelming majority who believe that it is not a disease entity, but the end result of an inflammatory process; Wolfsohn and Brandenstein [24], Schlagenhaufer [21], Bischoff [25], Schertlin [23], Doub [41], Henschen [18], Kienböck [26], Breus and Kolisko [27], Kuliga [13], Pomeranz [34], Loebel [37], Zwicker [38], Campbell [39], and Saupe [40] are in approximate agreement with this view. Many of these writers regard the condition as an extension of a

juvenile osteo-arthritis or other chronic deforming process, the deformity being manifested years after recovery from the original acute infection.

Numerous bacterial agents are variously believed to be concerned in the process, including the tubercle bacillus, the gonococcus, the streptococcus, etc. Such conditions as tabes, lues, metastatic malignancy, the arthritides, gouty diathesis, coxitis, chondrodystrophy, and trauma are among the other important factors believed, from an etiological standpoint, to be actively concerned.

Eppinger's article [12] appears to be the first scientific dissertation on the subject. From his study of four anatomical specimens, he attributed the affection to a disturbance in the acetabular development, of the nature of a chondritis or chondrodystrophy. Stated otherwise, he considered it a developmental anomaly of the acetabulum in which the persistent cartilage does not fuse, but is projected into the pelvic cavity; nevertheless he differentiates this condition from the chondrodystrophy of the dwarf or of the rickets type. His disregard of the tuberculous history in three of the four cases he described excluded, in his opinion at least, any causal relationship.

Kuliga [13] questions the importance of the cartilaginous changes, believing them to be secondary involvements. His case is of extreme interest, since it bears on the obstetrical significance of the lesion. His patient died of hemorrhage following delivery, and at autopsy a typical Otto deformity was found. This author considered it an osteo-arthritis and does not agree with Eppinger's theory of a chondrodystrophy. This was the first case which correlated the clinical and pathological material. In Benda's case [36] the intrapelvic protrusion interfered with labor, and a Caesarian section was performed. A female child was delivered on whose head a globular defect was noted. This pressure defect disappeared in a few days. This case contradicts Henschen's statement that unilateral cases would not produce obstruction in labor, nor would they hurt the soft tissues of the child or mother. Henschen [18] believes with Schlagenhaufer [21] that it was of gonorrhoeal origin.

The tuberculous basis of the condition, however, is suggested by several writers including Valentin and Müller [32]. Henschen [20], although excluding tuberculosis from the possible etiological factors, calls attention to the occurrence of a similar protrusion in the temporomandibular articulation in phthisis. Again, Hertzler [33] would exclude not only tuberculosis in the causation of this anomaly, but also tabes and osteomyelitis, and regards the affection as an osteo-arthritis. Chiari [31] disregards the history of tuberculosis in four of the eight cases which he reported; he also rejects the gonococcal theory, and reaffirms his original contention [28] of the tabetic etiology of the disease. Zwicker's [38] Cases 4 and 5 are evidently tuberculous in origin. Tregubow's [43] cases are obviously due to tuberculosis of the hip with perforation of the acetabulum. Although he described them as Otto pelves, they lack the protrusion and hyperostosis of a true Otto pelvis.

Féré [8] and Wrede [22] subscribe to the tabetic theory, and Bischoff [25] considers the etiological connection of tabes of interest in that it may explain the absence of more marked pain. White [9], in 1884, described a specimen from a woman found in the dissecting room of Guy's Hospital. The acetabular fossae protruded into the false pelvis. In view of the absence of productive changes, this writer doubted the luetic origin of the condition and submitted the specimen to Féré who in turn submitted it to Charcot. The latter identified it as a luetic arthropathy. White in a subsequent communication [9] stated that he was uncertain how to classify the lesion, and questioned the significance of the luetic history. On the other hand, Breus and Kolisko [27] hold the tabetic theory untenable because of the recent manifestations in the right hip joint in Chiari's [28] Case 8, an old destructive protrusion being present in the left hip joint. Yet this case was clinically and autoptically confirmed as due to tabetic arthropathy.

Several authors have stressed the rôle played by the gonococcus. Schlagenhaufer [21], in 1909, described a case which has often been quoted. This was a female patient forty years of age, in whose hip joint the gonococcus was found at autopsy. The joint changes were those of a typical destructive arthritis, with protrusion of the acetabulum and the head of the femur. Although convinced that the condition he presented was the extension of a gonorrhoeal arthritis, this investigator conceded that other inflammatory processes than one of gonococcal origin might theoretically also produce the same changes. Schlagenhaufer's case was regarded by Henschen [29] as the only case of intrapelvic acetabular protrusion of gonorrhoeal origin bacteriologically confirmed up to that time (1913). Breus and Kolisko [27] described three cases of Otto pelvis. They acknowledged as the only positively established etiological factor a gonorrhoeal coxitis, and rejected Henschen's suggestion of a tuberculous or tabetic origin. Breus's subsequent study [30] convinced him that the gonococcus was the only bacterium capable of producing all of the changes and sequelae noted in this condition. Although Kienböck [26] claimed that protrusion of the acetabulum was a rare finding in gonorrhoeal arthritis, nevertheless he attributed one of his cases to this source. His second case he believed due to a combination of lues and gonorrhoea. His explanation was that the gonorrhoeal arthritis caused rapid softening of the acetabulum with trophic disturbances of the bone; and that tabes caused gradual trophic disturbances of the bone with erosion and protrusion of the acetabulum and ossification of the periosteum. Zwicker's [33] Case 7 developed an intrapelvic protrusion after an acute gonorrhoeal infection.

The importance of metastatic malignancy as a causative agent in the production of this deformity has been discussed by several authors. In Thomsen's case [4] evidence of the neoplasm was found at autopsy.

Chiari [28] reported the case of a man (Case 7) who died of carcinoma of the biliary tracts, and Valentin and Müller [32] regarded Case 1 of their series as a case of a highly ossifying carcinoma.

The rôle played by trauma in Ponfick's [3] case, in a woman of fifty-one who sustained an injury sixteen years prior to the development of the lesion, has caused much controversy. This patient also had tabes which developed during pregnancy. Chiari [31] attributes the deformity in this case to trauma, and he considers Féré's and Henschen's [20] Case 2, as due to a combination of traumatic and gonococcal causes. It is probable that Benda's [36] case was traumatic in origin. Of the cases reported by Saupe [40], Cases 1, 2, and 3 are traumatic in origin.

Henschen [20] reported seven cases of echinococcus infection cited in the literature and indicated that the diagnosis usually was not made *intra vitam*, but at operation or autopsy. Granular destruction of the acetabulum and perforation were usually seen, and the acetabular fossae were sequestrated and punched out. The heads of the femora were usually involved in these cases. According to Kroenlein [7], echinococcus involvement occurs first in the soft tissue of the joint and secondarily in the bone. Trendelenburg [6] described the case of a man, thirty years of age, who had a suppurating fistula in the right hip. Rectal examination made at operation revealed a bony elevation near the acetabulum, the size of a fist and surrounded by echinococcus vesicles. A sequestrum was found within the acetabulum. This patient recovered following a resection. Doebbelin [11], in reviewing seventy-eight cases of echinococcus infection of the osseous system, reported pelvic involvement in twenty-three, and in only three cases had the infection spread from the pelvis to the femur. He reviewed the cases of Trendelenburg [6], Pihan [2], and Réczey [5].

Esau's case [16] (previously referred to) in a girl, ten years of age, who was suddenly seized with pain in the lower abdomen and died four weeks later, was diagnosed by him as an acute pyogenic osteomyelitis of unknown etiology. From the extensive bony destruction this investigator assumed that the process had its origin in the pubic bone, thence spreading to the acetabulum and ischium, and resulting in intrapelvic protrusion of the acetabulum. Froelich [44] described typical cases occurring in women, both of whom had been operated upon for tumors of the ovaries. In this connection, he called attention to a similar case reported by Verrall, and believed the deformity of endocrine origin.

The predominating characteristics as postulated by Henschen [18], in 1909 are: protrusion of the acetabulum; elevation of the rim of the acetabulum with eburnation; preservation of the femoral head and its migration into the acetabulum, and shortening of the extremity. On the other hand, four distinct stages of the process have been described by Breus and Kolisko [27],—namely:

(1). A localized destructive inflammation of the bony acetabulum.

(2). An almost complete preservation of the head and neck of the femur in the longitudinal axis.

(3). Intrapelvic protrusion of the acetabular periosteum, due to pressure from the femoral head.

(4). A rapid, smooth healing, resulting in a newly formed acetabular floor and permanent, dome-shaped, intrapelvic protrusion.

These investigators, including Henschen[29], believe that extension of the acetabular floor occurs during the initial stage; that development of the dome-shaped periosteum takes place during the intermediate stage; and that, during the terminal stage, periosteal ossification with definite Otto protrusion may be observed. A suggestion of this is seen in Schlagenhaufer's statement [17] that the following may be similar cases observed at different stages of the disease:

1. Schlagenhaufer's case.
2. Eppinger's Pelvis A.
3. Eppinger's Pelvis B.
4. Kuliga's case.
5. Eppinger's Pelvis 6 with Case 1, Breus and Kolisko.
6. Eppinger's Pelvis D, with Otto's Case 1, and Case 2 of Breus and Kolisko.

This last stage may be succeeded by various secondary bony changes of the joint, by hyperostosis, sclerosis, partial or total synostosis. Henschen and Breus and Kolisko are convinced that in the development of this disease the outstanding change occurs in the acetabulum, the femoral head being relatively uninvolved or secondarily involved; and Bischoff[25], Doub[41], and the writer[34] are in approximate agreement with this view. On the other hand, Otto[1], Ponfick[3], Féré[8], and Schlagenhaufer[21], have found the predominating changes in the femur, the head in some instances being practically denuded of cartilage and covered with granulations.

INCIDENCE

Valentin and Müller[32], in 1921, summarized thirty-one of the thirty-four cases reported up to that time, and of these only twenty were conceded by them to be typical. Their analysis is probably correct, if Case 2 of their series is included. Since that time forty-five additional cases have been reported, and of these twenty-one appear to be typical instances of intrapelvic protrusion, making in all approximately forty-one cases of true Otto pelvis reported to date. Despite the few recorded cases, the literature which has accumulated on the subject is truly enormous. Curiously enough this affection had been studied chiefly by the Germans, Hertzler's publication being the first American contribution on the subject.

In forty-seven of the seventy-nine cases reported, this deformity occurred in females. It is thus almost twice as common in females as in males. Persons in middle life have been most generally affected, the outstanding exceptions being one patient of advanced age—Chiari's Case 2, a man of seventy years,—and the following cases reported in individuals under twenty years of age,—Esau's case in a girl of ten; Zwicker's Case 4, in a girl of fifteen; Doub's Case 1, in a young woman of sixteen; and two young women, eighteen and nineteen years of age respectively, Valentin and Müller's Cases 2 and 3.

The disease was unilateral in forty-nine of the seventy-nine reported cases. In twenty-nine, the condition was bilateral; and in one case the side involved was not stated by the author.

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Otto	1824	o1	?	F	Bi-lateral	Gout	Specimen. Associated arthritis of sacro-iliac joint.
Pihan	1860	x1	27	M	Right	Coxitis	History of injury, followed by pyarthrosis. Echinococcus cysts found at autopsy. This case was reviewed by Doebbelin[11], and Tillmanns[14].
Ponfick	1872	o1	51	F	Right	Arthritis deformans	History of injury and tabes. Arthritis of hips and knees. Believed by Schertlin to be a typical case, but rejected by Breus.
Thomsen	1872	x1	40	F	Right	Metastatic malignancy	Operated upon for carcinoma of the breast. Autopsy revealed metastatic malignancy of the right hip.
Réczey	1877	x1	27	F	Right	?	Greatest protrusion of the acetabulum reported. Autopsy revealed echinococcus cysts. Reviewed by Doebbelin[11] and Tillmanns[14].
Trendelenburg	1881	x1	30	M	Right	Pyarthrosis	Echinococcus cysts found at operation. Reviewed by Doebbelin[11].
Féré	1882	x1	?	?	Right	Tabes	Specimen. Insufficient data.
White	1884	o1	?	F	Right	Charcot's disease	Specimen. Confirmed by Charcot. Believed by Schertlin to be typical case but rejected by Breus.
Eppinger	1903	oA	45	M	Right	Anomaly of growth	Specimen. Patient had pleurisy and tuberculous testicle. Probably tuberculous in origin. Accepted by Breus as a typical case.
Eppinger	1903	oB	35	M	Right	Anomaly of growth	Specimen. Patient had pulmonary tuberculosis, tuberculous caries of the spine, and tuberculous peritonitis. Accepted by Breus as a typical case.
Eppinger	1903	oC	?	F	Bi-lateral	Anomaly of growth	No data. Specimen. Henschen would exclude this case. Considered typical by Breus.
Eppinger	1903	oD	34	M	Left	Arthritis deformans	Miliary tuberculosis of the lungs, spleen, kidneys, and tuberculous adenitis. Accepted by Breus as true case.
Kuliga	1905	o1	45	F	Bi-lateral	Osteo-arthritis	First case reported having obstetrical difficulties. Autopsy confirmation. X-ray plates show typical deformity. Henschen and Schlagenhaufer consider this case of gonorrhoeal origin. Accepted by Breus as typical. Reviewed by Von Rosthorn[15].

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Esau	1908	x1	10	F	Right	Osteomyelitis	On puncture of hip, yellowish white pus was obtained which revealed chained streptococci. Autopsy confirmation. Evidently a true case.
Henschen	1909	o1	76	F	Bilateral	?	Tubingen Specimen 1. Died of cardiac disease. True case.
Henschen	1909	o2	?	F	Left	?	Tubingen Specimen 2. No data. Resembles Eppinger's Pelvis C.
Henschen	1913	o3	41	F	Bilateral	Coxarthritis or neuroarthropathy	Negative Wassermann and complement-fixation tests.
Schlagenhaufer	1909	o1	40	F	Right	Gonorrhoeal arthritis	First study from clinical course to autopsy. Gonococcus obtained on autopsy from hip joint and tissues.
Schertlin	1911	o1	40	F	Bilateral	Juvenile deforming arthritis	History of polyarthritis of twenty years' duration. X-ray plates submitted. Breus considers the etiology incorrect, but may still be gonorrhoeal.
Wolfsohn and Brandenstein	1911	x1	34	M	Right	Juvenile osteoarthritis	Condition evidently developed as part of polyarthritis. Connection with Otto pelvis not investigated. Rejected by Breus.
Bischoff	1911	o1	?	F	Bilateral	Arthritis deformans	Specimen. No history.
Kienböck	1912	o1	42	M	Bilateral	Tabes	History of gonorrhoea and syphilis. X-ray plates submitted.
Kienböck	1912	o2	32	F	Right	Gonorrhoea	History of gonorrhoea and eleven years later developed intrapelvic protrusion.
Breus and Kolisko	1912	x1	45	M	Right	Coxitis	Specimen. Patient died of pulmonary tuberculosis.
Breus and Kolisko	1912	x2	75	F	Right	?	Specimen. Patient died of acute purulent bronchitis.
Breus and Kolisko	1912	o3	?	?	Left	?	No history. Specimen loaned by Prague Pathological Museum.
Chiari	1916	o1	33	F	Left	Gonorrhoeal arthritis	Wassermann negative. Polyarthritis. On autopsy adnexa contained pus with gram positive and negative diplococci. Left hip contained pus which was negative for gonococci. Probably of gonorrhoeal origin.
Chiari	1916	x2	70	M	Right	Tuberculous or gonorrhoeal arthritis	Specimen. Patient died of genito-urinary tuberculosis. Insufficient data.
Chiari	1916	x3	?	M	Left	Tuberculous coxitis	Specimen. Insufficient data.

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Chiari	1916	x4	?	M	Left	Tuberculous coxitis	Specimen. Insufficient data.
Chiari	1916	x5	43	M	Bilateral	?	Specimen. Died of tuberculosis of lungs and peritoneum.
Chiari	1916	x6	73	M	Bilateral	Arthritis deformans	Specimen. Insufficient data.
Chiari	1916	x7	71	M	Bilateral	Arthritis deformans	Died of carcinoma of the biliary tract.
Chiari	1916	o8	52	F	Bilateral	Luetic arthritis	Symptoms of lues with positive Wassermann. Autopsy findings of generalized syphilis. Case originally reported in 1912.
Valentin and Müller	1921	x1	50	F	Left	Neoplasm	Carcinoma of adnexa. Patient received radium therapy. Died of cachexia.
Valentin and Müller	1921	o2	18	F	Left	Tuberculous coxitis	History of rheumatism and pleurisy. Positive tuberculin test. Radiographs submitted.
Valentin and Müller	1921	x3	19	F	Left	Arthritis	Rheumatism with cardiac involvement. Complement-fixation and Wassermann tests negative.
Hertzler	1922	o1	29	M	Bilateral	Polyarthritis	Author identifies this case with those reported by Wolfsohn and Brandenstein, Schertlin, and Henschen.
Hertzler	1922	x2	44	F	Left	Polyarthritis	History of injury. Confined to bed with fever. Sinus formed. Believed this case similar to Esau's case.
Hertzler	1922	x3	36	F	Left	Tuberculous arthritis	Treated for a hip condition as a child. Similar case reported by Chiari.
Hertzler	1922	x4	46	F	Left	Metastatic malignancy	Tumor of breast removed by caustic agent. Similar case reported by Valentin and Müller.
Pomeranz	1925	o1	31	M	Left	Osteoarthritis	History of cholecystitis. Serology negative.
Lewin	1925	o1	64	M	Left	Osteoarthritis	History of injury. Specific urethritis twenty years prior to examination.
Benda	1926	x1	42	F	Right	Coxitis	History of injury followed by disability. Caesarian section. First obstetrical difficulty. May be traumatic in origin.
Loebel	1927	x1	63	F	Right	Polyarthritis	Polyarthritic symptoms for eight years.
Loebel	1927	o2	51	F	Bilateral	Arthritis	History of injury to spine and hips. Associated arthritis of the sacro-iliac joints.
Loebel	1927	o3	53	F	Bilateral	?	Four years' duration. Typical waddling gait.

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Zwicker	1927	x1	56	F	Left	Arthritis	No data.
Zwicker	1927	o2	66	F	Left	Arthritis	Generalized arthritis of hips and knee joints.
Zwicker	1927	o3	?	F	Bi-lateral	Arthritis	Arthritis of the hip and knee joints.
Zwicker	1927	x4	15	F	Left	Tuberculous coxitis	Tuberculous arthritis. Involvement of the head of femur. Protrusion present.
Zwicker	1927	x5	26	M	Left	Tuberculous coxitis	History of injury followed by disability. Plates show ankylosing process in left hip.
Zwicker	1927	o6	?	F	Bi-lateral	Rickets	Old generalized rachitic deformities present.
Zwicker	1927	o7	?	F	Right	Gonorrhoeal arthritis	Hip lesion developed after gonorrhoeal urithritis.
Campbell	1928	o1	68	F	Left	Poly-arthritis	History of repeated attacks of rheumatism followed by deformities. X-ray plates show deforming arthritis of elbows, hands, and shoulders.
Campbell	1928	o2	64	F	Right	Poly-arthritis	History of polyarthritis of ten years' duration. X-ray shows chronic deforming arthritis of many joints.
Saupe	1928	x1	49	M	Left	Osteo-arthritis deformans	History of injury. Osteomyelitis of femur.
Saupe	1928	x2	52	M	Right	Osteo-arthritis deformans	Fracture of neck of femur, eleven years prior to observation. Probably traumatic.
Saupe	1928	x3	69	M	Right	Osteo-arthritis deformans	Injury to right hip, ten years prior to observation. Patient had Paget's disease. Probably fracture of acetabulum.
Saupe	1928	x4	?	M	Right	?	No data. Rejected.
Saupe	1928	o5	68	F	Left	Osteo-arthritis deformans	History of arthritis.
Saupe	1928	x6	?	?	?	Paget's disease	No data. Rejected.
Saupe	1928	o7	?	?	Left	Osteo-arthritis deformans	Specimen. No history. Associated destructive arthritis of right hip joint.
Saupe	1928	x8	?	?	Bi-lateral	Osteo-arthritis deformans	No data. X-ray plates only submitted. Ankylosing arthritis of sacro-iliac joints.
Saupe	1928	x9	?	?	Left	Osteo-arthritis deformans	X-ray plates only submitted. Insufficient data.
Saupe	1928	x10–11–12	?	?	Bi-lateral	?	No data. Rejected.

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Doub	1929	o1	16	F	Bi-lateral	Osteo-arthritis	History of typhoid and injury to left hip. Plates submitted.
Doub	1929	o2	50	F	Bi-lateral	Osteo-arthritis	History of rheumatism and typhoid. Plates submitted.
Doub	1929	o3	49	F	Left	Osteo-arthritis	Associated arthritis of the spine. Radiographs submitted.
Doub	1929	x4	53	F	Bi-lateral	Osteo-arthritis	Arthritis of the hips and spine. Not typical case. Plates submitted. No protrusion present.
Doub	1929	x5	44	F	Bi-lateral	Osteo-arthritis	History of scarlet fever, measles, and influenza. No true protrusion of the acetabulum present. Plates submitted.
Doub	1929	x6	35	M	Bi-lateral	Osteo-arthritis	Osteo-arthritis, with no protrusion. Plates submitted.
Doub	1929	o7	?	F	Right	Osteo-arthritis	Cases of Dr. Henderson. Roentgenograms show typical protrusion.
Doub	1929	o8	40	F	Right	Osteo-arthritis	Appear to be typical involvement. Plates submitted.
Verrall	1929	o1	34	F	Bi-lateral	Arthro-katadysis	Duration of twenty years. Operation for cystic ovary. Erroneous diagnosis of tumor palpable through vagina? Plates submitted.
Froelich	1930	o1	43	F	Bi-lateral	Intrapelvic protrusion	Discovered accidentally following x-ray examination for slight injury to right hip. Lesion antedated accident. No previous disability. History of operation for tumor of ovary at age of thirty-three.
Froelich	1930	o2	34	F	Bi-lateral	Intrapelvic protrusion	Progressive disability for past twenty years. No injury. Operated upon in 1922 for tumor of ovary. These cases resemble the one reported by Verrall.

x—Doubtful cases. o—Typical cases.

SYMPTOMS AND PHYSICAL FINDINGS

The chief complaint of the average case is that of a slowly progressing painful coxitis, which has lasted for months or years prior to the examination. With the coxitis, there develops a limp, which gradually becomes so severe that the patient walks with a wabbling gait and may find it impossible to spread the limbs or to stoop. If the deformity is great and the condition of long standing, all movements at the hip become completely restricted and walking is impossible.

Physical examination discloses distinct limitation of abduction and rotation of the femur. Outward rotation in particular appears to be restricted early in the disease. One may feel the greater trochanter grate against the pelvis or the lesser trochanter strike the ischium. The flexion deformity that occurs may be so great that the femur and pelvis form a right angle. Due to the migration of the femur, shortening of the extremity results. Kyphosis, lordosis, and pelvic rotation may be present, depending on the severity of the lesion in the hip. On abdominal palpation, a globular swelling, projecting into the pelvis from the inner aspect of the hip joint, may be felt above Poupart's ligament, and often in early cases the tumor may be readily demonstrated on rectal or vaginal examination.

ROENTGENOGRAPHY

The diagnosis even in early cases may be made by x-ray examination. The fundamental changes occur in the acetabulum. The disease results in an inward protrusion of the acetabulum, so that it projects into the pelvis as a rounded, globular, dome-shaped mass. The degree of protrusion varies from a few millimeters to four or five centimeters in severe cases. As the acetabulum migrates, it inclines upward, inward, and forward so that it may project above the ramus of the pubic bone, spreading towards the obturator fossa and at times materially encroaching upon and constricting it. In extreme cases, the protrusion extends up to the sacroiliac joint and, as a result, unilateral constriction of the pelvis occurs. The inner wall of the acetabulum may be shell-like in thinness or else occur as an extremely dense eburnated wall. As it extends into the pelvis, a low-grade osteoplastic process is initiated, whereby nature splints the yielding joint by the formation of a dense wall on the inner aspect of the acetabulum parallel to its projecting margin. The external margins of the acetabulum project outward over the neck of the femur as irregular serrated vegetative formations.

In the typical deformity, there is preservation of the integrity of the femoral head. This would seem to be a necessary prerequisite, since the femoral head must maintain its boring qualities. This is in the main true of all cases reported, although many of the specimens examined reveal destruction of the cartilaginous covering of the head. Occasionally, there may occur slight deviations from the general configuration of the head. It may appear mushroomed and at other times slightly elongated, assuming a spear-like, or spade-like, shape. Projecting outward from the articular surface of the head, bony excrescences are present which extend over the femoral neck. The constricted acetabular inlet, combined with the osteophytic projections from the head, effectually locks the femoral head within the acetabulum. The futility of conservative measures in such a situation must be obvious.

As the femur follows the receding acetabulum, there appears to be foreshortening of its neck. This change, however, is more apparent than real and is due to two causes,—first, the upward extension of the ace-

tabulum, followed by the sinking head; and second, the osteophytic protrusion from the femoral head which occurs at the expense of the neck.

As the head of the femur is submerged within the acetabulum, the trochanters approach the lateral margins of the pelvis and incline posteriorly. The greater trochanter impinges on the lateral margins of the ilium, in the region of the acetabular shelf and the lesser trochanter approaches the ischium. The position of the trochanters explains why the femur cannot be rotated outward or backward. In extreme cases, the acetabulum may show two facets,—a superior and fairly large facet for the femoral head, and a smaller inferior facet for the lesser trochanter. The arrest of the trochanters at the lateral margins of the pelvis limits the deformity. Further inward migration of the femur is impossible, its boring action is suspended, and the periosteum on the inner wall of the acetabulum becomes ossified. The active stage of the disease is thus terminated and the deformity is permanent.

CASE REPORTS

Case 1. Male, white, aged thirty-two, history number 10798. Admitted May 17, 1926, and discharged May 25, 1926. Diagnosis on admission: arthritis of the left hip.

Present History: In December 1921, the patient contracted a gonorrhoeal infection. Two weeks later his left ankle became inflammed and he was unable to support his weight on the involved extremity. He was treated by his family physician and the swelling subsided. Shortly after his recovery he took a four-mile walk, following which he experienced severe pain in the left hip. He was taken to an institution where he remained four months. At this hospital a plaster spica was applied to the hip for twelve days and his urethral infection treated at the same time. The pain subsided, but the hip became ankylosed. In December 1922, he entered another hospital and received baking and massage for six months. This treatment afforded him temporary relief, but the ankylosis of the hip remained. At still another institution which he visited, mobilization of the hip was attempted under a general anaesthetic.

Orthopaedic Status: Motion in flexion of the left hip was possible to only about forty-five degrees. Abduction was almost absent; internal and external rotation impossible. There was shortening of the extremity amounting to about three-quarters of an inch. There was no local tenderness over the involved hip, but a globular mass was present on the inner aspect of the acetabulum. The ankle joint was not involved.

Smear, complement-fixation, and Wassermann tests were negative. X-ray examination shown in Figure 3.

Case 2. Male, white, aged forty-four. Admitted February 4, 1929, and discharged March 9, 1929. Diagnosis on admission: arthritis of the left knee and hip.

Present History: Four weeks prior to admission was confined to bed by influenza. This was followed by pain in left shoulder, wrist, knee, and hip in the order described. Received injections which relieved the pain somewhat. Three days prior to admission suffered excruciating pain in left hip and lower extremity. "Felt paralyzed."

Orthopaedic Status: Middle-aged, white, male, who was apparently in great pain. Patient lay in bed on left side with knees flexed. In the right lower extremity, there was no limitation of motion, but slight pain on pressure over gluteal fold. Left hip was held flexed but could be moved somewhat, although patient complained of pain in the hip and knee. There was marked tenderness over left groin on pressure. Left knee, negative. Spine, negative.

Temperature on admission was 102.8 degrees; respiration 32; and pulse 120. Throughout his stay in the institution his temperature ranged from 98.8 to 103 degrees.

Complement-fixation and Wassermann tests were negative. Blood chemistry showed 120 milligrams of sugar per 100 cubic centimeters of blood. First x-ray examination on February 4, 1929, shown in Figure 4. On February 7, 1929, patient noticed a thin mucoid discharge from the urethra, which bacteriologically was negative. On March 7, 1929, the contraction deformity of the left hip was corrected and traction applied. A cast was then applied which was removed on August 5, 1929. In December 1929, the patient was again seen, and at that time, a typical intrapelvic protrusion of the left acetabulum was revealed (Fig. 5).

FIG. 3

Case 1. Note intact femoral head. Sclerotic changes predominate, marginal spurs on acetabulum and head of femur.

CASE 3. Male, white, aged thirty-one. Admitted November 6, 1924. Diagnosis on admission: infectious arthritis.

The previous surgical history was negative. The previous medical history was of interest. While serving as a soldier in the latter half of 1917, he was taken acutely ill and was sent to a base hospital, where he was treated for a gall-bladder condition associated with fever. The patient's history indicated that the condition was a cholecystitis rather than a cholelithiasis. He remained in the hospital for one month and then was discharged as cured. No history of jaundice was obtained. Blood and serological examinations at that hospital were negative; as they were also at our institution.

Present History: Two weeks after discharge from the base hospital, while walking, he was seized with a sudden sharp pain in the left hip which soon became so severe as to incapacitate him. This pain was knife-like, and remained localized in the left hip. It was aggravated on walking and on exercise, and was somewhat relieved by rest. At the end of one week he was able to be up and about, the pain had left, but some disability remained. The past eight years witnessed a cycle of this sequence: a recrudescence of pain followed by relief after varying periods, to be succeeded by progressively increasing disability, so that at time of admission only limited motion was possible in the left hip.

Orthopaedic Status: General condition and physical examination were negative except for the left hip. There was some muscular atrophy as well as a limitation of all movements about the hip except in flexion and extension. Abduction and external rotation were most restricted, adduction and internal rotation less so. X-ray examination, November 6, 1924 (Fig. 6).

CASE 4. Female, white, married, aged forty-four, history number 10978. Seen in the dispensary August 26, 1928. Clinical diagnosis: osteo-arthritis of both hips.

Previous History: Negative.

FIG. 4

Case 2. Complete obliteration of hip joint by destructive process, involving particularly the articular surface of the acetabulum. Femoral head intact.

FIG. 5

Case 2. Same case as preceding, ten months later. Marked inward protrusion of the acetabulumate. Slight increase in the width of the joint space, with modern erosion of the head of the femur.

Present History: Pain in the sacro-iliac and hip joints for the past year, aggravated during the past three months. The pain appears to begin in the sacro-iliac regions and hip joints, and radiates down the thighs. Symptoms appear to be worse on the left side.

Orthopaedic Status: Patient walked with a waddling gait. Abduction and adduction of the thighs were almost impossible; rotation almost nil. Slight flexion deformities were present; further flexion was possible only when both thighs were flexed together. Both hips appeared to be partially ankylosed. There was marked tenderness over both sacro-iliac joints. X-ray examination, August 26, 1929 (Fig. 7).

FIG. 6

Case 3. Note vacuolated area in the newly formed inner surface of the left acetabulum. Bone abscess(?). Head of femur intact. Joint space clearly defined.

CASE 5. Female, white, aged fifty-eight, history number 35245. Examined in clinic January 10, 1928. Diagnosis: polyarthritis.

Chief Complaint: Pain in the hips and right knee.

Previous History: Negative.

Present History: For the past three years patient had experienced irregular pains in the hips and right knee, most severe during inclement weather. The pain was dull in character, radiating from the back downward along both thighs. The pain in the back (in the sacro-iliac regions) was constant in character and relieved only by rest and heat. The pain in the hips and right knee was evanescent in character. For the past eighteen months, had noted increasing limitation of both hips.

Orthopaedic Status: Patient walked with a slight waddling gait. There was marked restriction of all movements in both hips, particularly on the right side. Rotation and abduction in particular appeared to be restricted. There was a moderate periarticular swelling of the right knee joint without any restriction in motion. Varicose veins were present in both legs and examination of the feet revealed distinct tenderness over the heads of the metacarpal bones. No complement-fixation or Wassermann tests were performed. X-ray examination revealed fairly early and typical osteo-arthritic protrusion of the acetabula, synostosis of the right sacro-iliac joint, and beginning ankylosis of the left sacro-iliac joint (Fig. 8).

CASE 6. Female, white, married, aged thirty-two, history number 56458. Seen in the dispensary September 26, 1928. Clinical diagnosis: osteo-arthritis of the hips.

Previous History: Negative.

Present History: The onset of the present condition began insidiously about eighteen months before, with slight pain in both hips. During the past year the pain had been more or less continuous and appeared to be worse on the right side, apparently beginning in the hips and radiating down the thighs. With the pain, there had been

some limitation in motion, particularly on the right side. During the past three months, there had been a vaginal discharge.

Orthopaedic Status: Flexion in both hips was markedly restricted. There was a moderate adduction contraction present, on both sides; abduction restricted. No rectal examination was done. Examination of vaginal smear revealed no gonococci. X-ray examination, September 26, 1928 (Fig. 9).

COMMENT

The definite history of a proven gonorrhoeal infection, followed immediately thereafter by involvement of the ankle and hip joints, reasonably establishes Case 1 as of gonorrhoeal origin. The radiograph shows a typical intrapelvic protrusion of the acetabulum.

Case 2 is of extreme interest. This patient developed an acute arthritis of the hip following influenza, and an x-ray examination at the time revealed practically complete obliteration of the joint space due to destruction of the cartilage, with undermining of the acetabulum. Although the influenza bacillus was not definitely identified as the causative agent it is at least permissible to assume that the condition followed an acute systemic infection. The destructive process as demonstrated by the x-ray manifested itself in its early stages by involvement of the

FIG. 7

Case 4. Bilateral involvement. Note irregularity of the inner surface of the left acetabulum, as well as of the head of the femur. Almost complete synostosis of the right sacro-iliac joint.

acetabulum chiefly, leaving the femoral head intact. Within eleven months of the acute infection, the maximum deformity had developed and was demonstrated roentgenologically. Even at this stage, it is evident from the roentgenogram (Fig. 5) that the maximum damage had occured, not in the femoral head, but in the acetabulum. This case records roentgenologically the onset of the disease and the final deformity.

The roentgenogram of Case 3 is that of a typical intrapelvic protrusion. This case has been previously reported. The interpretation given was that the vacuolated areas in the newly formed inner wall of the acetabulum are small abscesses, and that the dense bone produced is a reactive phenomenon, similar to that seen in cortical abscesses in long bones. The source of infection was probably the biliary tract.

The history of arthralgia over a period of years, as well as the roentgenological and physical evidences of a rheumatic process in the spine and hip joints, point to a common etiology with the lesions of the hips in Cases 4, 5, and 6. In these instances, the hip joints share in the process simply as a non-specific arthritis.

FIG. 8

Case 5. Bilateral involvement. Note complete synostosis of both sacro-iliac joints with localized area of eburnation in the left sacro-iliac joint. Associated arthritis of the lumbar spine. Femoral heads intact. Joint spaces clearly defined.

FIG. 9

Case 6. Bilateral involvement. Note eburnation of articular margins of bones of left sacro-iliac joint. Femoral heads intact. Joint spaces clearly defined.

DISCUSSION

In the review of the subject herein presented, it is evident that there is considerable speculation regarding the etiology of the lesion. Confusion regarding its origin appears to be due to attempts by various authors to consider it a disease entity, having as its origin a specific bacterium. We regard this view as fallacious. A careful perusal of the protocols establishes the fact that the condition may be produced by any process which involves essentially the acetabulum and leaves the femoral head intact. Stated otherwise, any disease resulting in a localized osteomalacia of the acetabulum can produce the deformity, providing the femoral head maintains its boring qualities. Most authors agree that theoretically this is possible. The destructive process, however, must not be too severe and must permit bone regeneration.

We have already seen that, of all the cases quoted in the literature, Schlagenhaufer's remains the only one in which the gonorrhoeal origin of the disease appears to have been established. To accept the findings in a single case as indisputable evidence proving any contention would obviously be extremely hazardous and contrary to scientific methods. There are many objections to this theory. No other observer has isolated the gonococcus from an involved hip. It is the experience of most orthopaedic surgeons that gonorrhoeal joints are acute, destructive, and often result in ankylosis or synostosis. The histories of cases of intrapelvic protrusion are those of a slowly developing and not severely acute progressive deformity. When gonorrhoeal ankylosis occurs, it is bony in character; whereas the fixation that occurs in an Otto pelvis appears to be

due to numerous small bone blocks within the joint; in other words no true ankylosis exists. While Schlagenhaufer admitted that intrapelvic protrusion of the acetabulum was rare in gonorrhoea, he attributed its infrequency to the effectual employment of therapeutic measures. While it is true that rest and traction might limit the deformity, its effect on subsequent ankylosis would be nil. How would one explain, then, the absence of more frequent intrapelvic protrusion in cases of established gonorrhoeal arthritis of the hip?

Similar objections can be stated for the pyogenic infections. In this instance, there is an acute onset, stormy course, and constitutional reaction. These organisms readily destroy articular cartilage, obliterate the joint space, and ultimately result in ankylosis. The Otto deformity progresses slowly and shows only moderate destruction of cartilage, but there is, as a rule, retention of the general contours of the articulation. In all our cases the femoral heads and the articular surfaces of the acetabula were still clearly visible, although the deformities were extreme. A subluxation of the hip is found occasionally during the acute stage of a pyogenic infection. The displacement, however, is usually lateral and external and not intrapelvic. Notwithstanding the frequency of such cases in our institution, intrapelvic protrusion in pyarthrosis is uncommon. Our Case 2, is of this type. Our explanation is that the infectious process is too virulent and disabling to permit of any regenerative effort. Destructive changes predominate and the process subsides either with moderate disability or else with ankylosis. Often in the pus infections, the process involves particularly the femoral head and results in its necrosis, and effectually prevents any migration of the acetabulum. According to Henschen's postulate, the boring capacity of the head must be retained in order to produce the protrusion. Hence, in this instance, the loss in the integrity of the head prevents the production of the deformity. It is important to remember, moreover, that rest in bed by itself would tend to prevent the deformity, in that it removes the thrust of the femur on an already weakened acetabulum.

On the other hand, the attenuated infections may, since they are not severely destructive, permit of bone regeneration in an acetabulum, the seat of a low-grade inflammatory process. In this instance, the initial disability would not be great; confinement in bed would be unnecessary; and, as a result, motion and weight-bearing would provide the mechanical conditions necessary for the production of the deformity.

Numerous true cases of intrapelvic protrusion have been reported in patients undoubtedly suffering from tuberculosis. On analyzing the basic process involved in tuberculous coxitis, one is prone to believe that conditions favoring intrapelvic protrusion are present. In tuberculosis, the infectious process burrowing under the acetabular cartilage results in pronounced osteomalacia. Muscular spasm, combined with flexion, adduction, and inversion of the extremity, would seem to favor the production of the deformity. Clinically, however, the picture is not that of

tuberculosis. The striking feature in all the cases is the history of a slowly progressing deformity in a patient usually beyond middle age at a time when tuberculous coxitis is uncommon. Roentgenologically, the absence of bone atrophy and the presence of bone production in the hip would seem to exclude it.

When Charcot's disease, Paget's disease, osteomalacia, and metastatic malignancy occur in the bones of the pelvis, they often result in intrapelvic protrusion of the acetabulum. In Charcot's disease we have the combination of osteomalacia associated with hyperostosis, whereas in osteitis deformans and neoplastic diseases of the pelvis, the resulting bone softening encourages the development of the deformity. We must recognize, however, that the deformity here is but a local manifestation of a general disease, and that, in Paget's disease and osteomalacia, the picture of an intrapelvic protrusion is complicated by the generalized bowing or deformities both of the pelvis and femora. In Charcot's disease, the protrusion of the acetabulum is accompanied by the extreme hyperostosis and fragmentation of the femora characteristic of this disease.

Eppinger's theory of a chondrodystrophy assumes that the three cartilaginous plates of the acetabulum remain unfused and are projected into the pelvis by the pressure of the head of the femur. In the known chondrodystrophies, this deformity had not been described. We would consequently have to ascribe the protrusion to an as yet unknown disease involving solely the cartilaginous plates of the acetabulum and resulting in its protrusion.

On the whole, it seems advisable to recognize two different classes of intrapelvic protrusion: (1) an acute type probably infectious in origin; (2) a chronic type occurring in the course of any disease, resulting in an osteomalacia of the hip joint.

(1). If the infection or inflammation has involved essentially or accidentally the acetabular surface of the hip joint, the femoral head remains intact and the protrusion quickly develops. If the infection is severe and involves the head of the femur and the acetabulum, there is necrosis of the head and bony ankylosis may result before the deformity occurs.

(2). The secondary type may occur in polyarthritis and in general osseous diseases,—such as syphilis, osteomalacia, and Paget's disease. In this instance, the hip lesion is but an incident in the general deformity.

Many of the cases presented evidence of an arthritic process elsewhere, commonly in the sacro-iliac joint and spine, and often in the knees, wrists, and elbows. In many instances, the patients had attacks of acute articular rheumatism which preceded by years the discovery of the hip lesion. Is it unreasonable to assume that herein lies the clue to the etiology? Is not the Otto pelvis an atypical but essentially non-specific arthritis of the hip joint? We must abandon our conception of the specificity and individuality of this lesion of the hip joint.

The author wishes to acknowledge the aid of Miss D. Moldenhauer of the New York Academy of Medicine in the German translations.

BIBLIOGRAPHY

1. Otto, A. W.: Pfannenbeckenmisstaltung Infolge Deformierender Osteoarthritis. *In* Neue Seltene Beobachtungen zur Anatomie, Physiologie und Pathologie Gehörig. Ed. 2. Berlin, A. Rücker, p. 19, 1824.
2. Pihan: (Demonstration.) Bull. Soc. Anat. de Paris, V, 363, 1860.
3. Ponfick: (Demonstration.) Berliner Klin. Wchnschr., IX, 580, 1872.
4. Thomsen, F.: Krebsige Osteomalacie. Arch. f. Klin. Chir., XIII, 235, 1872.
5. Réczey, E.: Ueber Knochenechinococcen. Deutsche Ztschr. f. Chir., VII, 288, 1877.
6. Trendelenburg, R.: Echinococcus Multilocularis der Rechten Beckenhälfte. Verhandl. d. Deutsch. Gesellsch. f. Chir., X, 60, 1881.
7. Kroenlein, U.: Die Destructionsluxationen (Volkmann). Deutsche Chir., XXVI, 116, 1882.
   Die Lehre von den Luxationen. Zentralbl. f. Chir., IX, 344, 1882.
8. Féré, C.: Description de Quelques Pièces Relatives aux Lésions Osseuses et Articulaires des Ataxiques Conservées au Musée Anatomo-Pathologique de la Salpêtrière. Arch. de Neurol., IV, 202, 1882.
9. White, W. H.: A Case of Charcot Affecting Both Hip Joints. Lancet, I, 391, 1884.
   On Charcot's Joint Disease. Lancet, II, 50, 1884.
10. Targett, J. H.: Hydatids in the Bony Pelvis. Trans. Obstet. Soc. of London, XXXVI, 344, 1895.
11. Doebbelin: Ueber Knochenechinokokken des Beckens. Deutsche Ztschr. f. Chir., XLVIII, 38, 1898.
12. Eppinger, H.: Pelvis-Chrobak, Coxarthrolisthesis-Becken. Beitr. z. Geburtsh. und Gynäk. (Festschr. f. Chrobak), II, 176, 1903.
13. Kuliga, P.: Über "Chrobak'sche Becken". Zieglers Beitr. z. Path. Anat. (Festschr. f. Arnold), XXXVIII, Supplement 7, 661, 1905.
14. Tillmanns, H.: Die Verletzungen und Chirurgischen Krankheiten des Beckens. Echinococcus des Beckens. Deutsche Chir., LXIIa, 462, 1905.
15. Von Rosthron: Einige Seltene Beckenformen. Verhandl. d. Deutsch. Gesellsch. f. Gynäk., XI, 168, 1905.
16. Esau, P.: Akute Osteomyelitis des Rechten Schambeins und Zentrale Pathologische Luxation des Oberschenkels. Deutsche Ztschr. f. Chir., XCI, 611, 1907–08.
17. Schlagenhaufer, F.: Über Coxitis Gonorrhoica und Ihre Beziehung zur Protrusion des Pfannenbodens. Virchows Arch. f. Path. Anat., CXCIV, 182, 1908.
18. Henschen K.: Die Intrapelvine Verwölbung und die Centrale Wanderung der Hüftpfanne. Bruns Beitr. z. Klin. Chir., LXV, 641, 1909.
19. Henschen, K.: Die Traumatische Luxatio Centralis Femoris, mit Besonderer Berücksichtigung Ihrer Geburtshilflichen Bedeutung. Bruns Beitr. z. Klin. Chir., LXII, 294, 1909.
20. Henschen, K.: Die Pathologische (Spontane) Luxatio Centralis Femoris. Bruns Beitr. z. Klin. Chir., LXV, 599, 1909.
21. Schlagenhaufer, F.: Über Coxitis Gonorrhoica und Ihre Beziehungen zur Protrusion des Pfannenbodens. Zentralbl. f. Gynäk., XXXIII, 228, 1909.
22. Wrede, B.: Diskussion zu den Klinischen Demonstrationen von Herrn Engelhorn. Naturw. Med. Ges. zu Jena, in Münchener Med. Wchnschr., LXII, 1728, 1915.
   Demonstration eines Tabesbeckens und eines Otto-Chrobakschen Beckens. Verhandl. d. 82. Versamml. Gesellsch. Deutsch. Naturf. u. Aerzte in Königsberg, LXXXII, 115, 1910.
23. Schertlin: Über einen Fall von Intrapelviner Vorwölbung und Centraler Wanderung der Hüftpfanne. Bruns Beitr. z. Klin. Chir., LXXI, 406, 1910–11.
24. Wolfsohn, G., und Brandenstein, S.: Ueber Osteoarthritis Coxae Juvenilis Duplex. Arch. f. Klin. Chir., XCVI, 656, 1911.
25. Bischoff, K.: Ein Beitrag zur Kenntnis der Otto Chrobak'schen Beckendeformität. Inaug. Diss. Königsberg i. Pr. 1911.

26. Kienböck, R.: Über die mit Protrusion des Pfannenbodens Einhergenhenden Erkrankungen des Hüftgelenks und Ihre Beziehungen zur Arthritis Gonorrhoica und Arthropathie bei Tabes. Fortschr. a. d. Geb. d. Röntgenstrahlen, XVIII, 280, 1911–12.
27. Breus, Carl, und Kolisko, Alexander: Die Pathologischen Beckenformen. Leipzig und Wien, Franz Deuticke, III, 540, 1912.
28. Chiari, H.: Becken mit Intrapelviner Pfannenprotrusion bei einer Tabica. Verhandl. d. Deutsch. Gesellsch. f. Path., XV, 329, 1912.
29. Henschen, K.: Die Zentrale oder Intrapelvine Pfannenwanderung der Hüfte auf Coxitisch-arthropathischer Grundlage. Ztschr. f. Orthop. Chir., XXXIII, 438, 1913.
30. Breus, C.: Zur Ätiologie und Genese der Ottoschen Protrusion des Pfannenbodens. Wiener Klin. Wchnschr., XXVI, 167, 1913.
31. Chiari, H.: Ueber die Aetiologie und Pathogenese der Intrapelvinen Pfannenprotrusion. Bruns Beitr. z. Klin. Chir., CII, 318, 1916.
32. Valentin, B., und Müller, H.: Intrapelvine Pfannenvorwölbung (Pelvis Otto-Chrobak). Arch. f. Klin. Chir., CXVII, 523, 1921.
33. Hertzler, A. E.: Osteo-arthritic Protrusion of the Acetabulum (Intrapelvic Pfannenvorwölbung). Arch. Surg., V, 691, 1922.
34. Pomeranz, M. M.: Osteoarthritic Protrusion of the Acetabulum. A Case Report. Am. J. Surg., XXXIX, 169, 1925.
35. Lewin, P.: Osteo-arthritic Protrusion of the Acetabulum. Surg. Gynec. Obstet., XLI, 449, 1925.
36. Benda, R.: Beitrag zur Kasuistik und Pathogenese der Coxitischen Pfannenprotrusion. Arch. f. Gynäk., CXXIX, 186, 1926–27.
37. Loebel, R.: Zur Protrusion der Hüftgelenkspfanne. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVI, 642, 1927.
38. Zwicker: Über Pfannenbodenvorwölbungen (Protrusio-Acetabuli) im Roentgenbild. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVI, 1008, 1927.
39. Campbell, D.: Über Endzustände der Chronischen Polyarthritis und die dabei Vorkommende Protrusio Acetabuli. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVII, 853, 1928.
40. Saupe, E.: Zur Sogenannten Protrusio Acetabuli. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVII, 1, 1928.
41. Doub, H. P.: Intrapelvic Protrusion of the Acetabulum. Radiology, XII, 369, 1929.
42. Verrall, P. J.: An Unusual Bilateral Condition of the Acetabula. J. Bone and Joint Surg., XI, 39, Jan. 1929.
43. Tregubow, S.: Die Perforatio Acetabuli bei der Coxitis Tuberculosa. Orthopaedia i Travmatologia, XIII, 17, 1929; Ztschr. f. Orthop. Chir., L, 548, 1928.
44. Froelich, M.: Migration Intrapelvienne Progressive de la Tête Fémorale et Lésion de l'Ovaire. Rev. d'Orthop., XVII, 553, 1930.

ARTHROKATADYSIS OF THE HIP JOINT *

BY N. AUSTIN CARY, M.D., F.A.C.S. AND LEONARD BARNARD, M.D.,
OAKLAND, CALIFORNIA

In January, 1929, P. J. Verrall [1] of London reported a case in which the lesion presented a sinking-in of the acetabulum, resulting in limitation in movement of the hip joint. He suggested the name "Arthrokatadysis", meaning literally "subsidence of a joint", and suggested that it may be a localized osteomalacia. He drew attention to the fact that there was no narrowing of the pubic arch as seen in true osteomalacia.

We wish to present two cases which have come under our observation, which we believe belong in this group. From these cases we are unable to throw any further light on the etiology of this condition, and are presenting them in the hope that further reported cases may lead to some appreciation of the etiology of these lesions.

CASE 1. Mrs. T. H., female, married, white, housewife, thirty-seven years of age.

History: Fifteen years ago, following childbirth, she had a "milk-leg". Since that time she has had trouble with the hip joint on this side. In general has been quite well: has had two children since the onset of the present complaint. Pain is described as burning in type, located in the hip-joint area, has become progressively more severe since onset, and is less in the morning and worse toward evening. There has been progressive diminution in motion in this hip until, at present, there is practically no ability to adduct or abduct it. She has worn plaster casts, but gets the greatest relief from a walking caliper. She wears this when she has hard work to do.

Physical examination: Medium-sized, normal-appearing woman, weighing 148 pounds. The examination was negative except for the left leg, which showed atrophy (moderate) of the musculature about the hip, one-fourth inch shortening. The motions of the hip joint were free in flexion and extension, but there was no demonstrable abduction or adduction.

X-ray examination (Fig. 1): Anteroposterior stereoscopic views of hips show a sinking-in of the left acetabulum into the pelvis, with thinning of the acetabular floor. The head of the femur, enlarged, was thoroughly engaged in the center.

CASE 2. No. 2292, Miss E. J., forty-three years of age, white, single, American, occupation—housekeeper. First seen March 29, 1929, at which time there was complaint of pain in the left hip joint.

History: Four years previous she had had pain in her left knee, which was diagnosed as rheumatism. Several teeth were removed, but without relief, and the condition became progressive. She was then confined to bed for five months, during which time she was free from pain, but, on returning to her feet, there was a recurrence of the old symptoms. Later a hip spica was used for immobilization, but, on removal and resumption of weight-bearing, the symptoms again reappeared. Her main complaint at the time of examination was pain in the left knee, thigh, and hip, on attempting to rise from a sitting position, but which was somewhat lessened by rotating the knee inward before arising. Patient denied any serious illnesses or injury; always had been well and strong. Habits have been normal and history was negative for any pathological findings.

Physical examination: Muscular woman; tall, erect, heavy frame, weighing 185 pounds; appeared in good health and well nourished. Tonsils absent; throat normal.

* This report of two cases of this unusual affection was received soon after the article by Dr. Pomeranz (page 663). This is of special interest, supplementing, as it does, the review of cases in the literature as presented by Dr. Pomeranz.

General and local examinations negative except for left leg. Left leg showed one centimeter shortening. Hip joints showed: flexion—right 130 degrees, left 130 degrees; extension—right 180 degrees, left 180 degrees; abduction—right 45 degrees, left 15 degrees; adduction—right 30 degrees, left 30 degrees. Character of motion was normal except for limitation in abduction of the left, which produced pain when forced. Musculature of thighs was of good tone and strength. Other joints were normal. Reflexes were normal and equal. Gait was normal.

X-ray examination: Anteroposterior stereoscopic views of the pelvis (Fig. 2) show localized dislocation of acetabulum and head of femur, much more marked on the left, with the neck apposing the rim of the acetabulum and accounting for limitation in abduction. Other joints were normal.

Laboratory tests showed: Urine, normal; basal metabolism, minus 2; blood, negative; Wassermann, negative.

Treatment by physical therapy—baking, massage, and manipulation—for four weeks gave no noticeable improvement.

DISCUSSION

CASE 1 permits of the suggestion that concurrent with her phlebitis at onset there may have been a vascular disturbance in the nutrition of the acetabulum on that side, which resulted in a localized softening and displacement on weight-bearing.

In CASE 2, the bilateral nature of the condition suggests some general disturbance. Her general appearance suggested some glandular dys-

FIG. 1

Case 1. Roentgenogram of pelvis showing sinking-in of left acetabulum, with central dislocation of the femur. Note the trochanter and neck riding on the rim of the acetabulum, blocking motion.

FIG. 2

Case 2. Roentgenogram of pelvis shows the sinking-in of both acetabula, followed by the femoral head, much more marked on the left where serious limitation in motion is present.

trophy, but none could be shown by the usual laboratory and clinical procedures.

SPECIAL NOTE

Since the above has been written we have found, under the title of "Osteo-Arthritic Protrusion of the Acetabulum", reference made by Hertzler[2] to a pathological condition of the hip joint which is closely comparable to the case reported by Verrall, as well as to our two cases. He has also collected the cases reported in the literature and cites those of Valentin and Müller, Lewin[3], and Pomeranz[4], the latter believing only twenty-two cases have been reported. We prefer the name of "Arthrokatadysis", as we believe it more correctly describes the condition.

REFERENCES

1. VERRALL, P. J.: An Unusual Bilateral Condition of the Acetabula. J. Bone and Joint Surg., XI, 39, Jan. 1929.
2. HERTZLER, A. E.: Surgical Pathology of the Diseases of Bones. Philadelphia, J. B. Lippincott Company, pp. 120–124, 1931.
3. LEWIN, P.: Osteo-Arthritic Protrusion of the Acetabulum. Surg. Gynec. Obstet., XLI, 449, 1925.
4. POMERANZ, M. M.: Osteoarthritic Protrusion of the Acetabulum. A Case Report. Am. J. Surg., XXXIX, 169, 1925.

TUBERCULOSIS OF THE FIFTH LUMBAR VERTEBRA WITH SPINA BIFIDA OCCULTA. SPINAL FUSION AND CURE

Case Report

BY MYRON O. HENRY, M D., MINNEAPOLIS, MINNESOTA

Tuberculosis of the fifth lumbar is rarely seen, and the surgical cure of such a case with concomitant spina bifida occulta seems worthy of record. On account of the long duration of the illness and the general condition of the patient, operative treatment was advised although the boy was only ten years of age. Multiple bone-chip transplants, taken from the tibia, were employed to form two lateral struts because of the absence of spinous processes and laminae in the affected region. Fusion of the spine followed, with calcification of the anterior abscess, and the patient was ambulatory and apparently cured one year later. His condition has improved steadily to date, and now (nearly six years after operation) he is symptomless, has no disability, and the fusion has not interfered discernibly with his growth in height.

CASE HISTORY

Boy, aged ten. Family history was of no importance. Past history was negative except for measles, scarlet fever, and tonsillectomy two years before. The parents dated

Fig. 1

Tuberculous fifth lumbar vertebra before operation. Note deficient laminae of fifth lumbar and first two sacral segments, also shadow of anterior abscess.

Fig. 2

Lateral view of Fig. 1, showing destruction of body of fifth lumbar vertebra, slight anterior dislocation, and abscess.

FIG. 3

Same as Fig. 1, eleven months after spinal fusion with multiple bone-chip transplants.

FIG. 4

Same as Fig. 2, eleven months after operation. Note new bone formation posteriorly.

FIG. 5

Same as Fig. 1, nearly six years after spinal fusion.

FIG. 6

Lateral view of Fig. 5, showing strong bony fusion, diminution in size of calcified abscess, and growth of vertebral bodies.

back the present illness to a fall eight years ago which was diagnosed "fracture." Subsequent back complaints were treated for rheumatism and scoliosis. A knuckle appeared in the back a few years ago. The patient was ambulatory, though complaining, until eight weeks ago when he took to his bed because of back pain, headache, and fever. He had not gained in weight recently.

On examination the patient was able to stand, but carried his back straight and inclined forward from the hips. Walking was slow and obviously painful. A definite knuckle was apparent at the level of the spinous process of the fourth lumbar vertebra. Marked muscle spasm prevented motion of the lumbar spine. No abscess was palpable, but extension of the hips was painful. The pulse was rapid and there was slight elevation of temperature.

X-rays revealed advanced destruction of the body of the fifth lumbar vertebra (Fig. 1) with lack of fusion of the laminae of the fifth lumbar vertebra and absence of the laminae of the first two sacral segments. The shadow of an anterior abscess was shown, together with slight anterior dislocation of the diseased vertebral body (Fig. 2).

At operation the muscles and periosteum were reflected laterally from the second lumbar vertebra to the mid-sacrum. A fibrous membrane replaced the deficient laminae of the first two sacral segments. The posterolateral articulations between the second, third, fourth, and fifth lumbar vertebrae and the sacrum were exposed and denuded of cartilage with a curet after the technique of Hibbs. Osteal shavings were removed from the remaining laminae of the lumbar vertebra and sacrum to expose raw bone. Many bone-chip transplants were then removed from the subcutaneous portion of the tibia and added to the above mass of shavings and chips so as to form two lateral struts from sacrum to the lumbar spine. The wound was closed in the usual manner.

No fixation dressings except pillows were employed until the stitches were removed on the twelfth postoperative day. Plaster-of-Paris shells were then made and the patient discharged home for heliotherapy and general antituberculous régime. The convalescence was entirely uneventful. New shells were made in four months and the boy was allowed to be ambulatory in a brace eleven months after operation (Figs. 3 and 4).

The patient has improved steadily to date. He has grown apparently normally and presents an excellent physique. His lumbar spine is solidly fused and causes him no disability though he is doing heavy farm work.

REDUCING DIET IN ORTHOPAEDIC SURGERY *

BY EMIL S. GEIST, M.D., MINNEAPOLIS, MINNESOTA

Orthopaedic Surgery is essentially the surgery of the connective tissues.

Today we deal with the lowliest type of connective tissue,—fat. We will consider fat as it affects weight-bearing in orthopaedic patients. Fortunately, as a rule, it is the most easily controlled tissue in the body.

"*Weight-Bearing*".—Up to now orthopaedic surgery has focused its attention on the latter half of this word. Our efforts have been largely concentrated on the "bearing"—the portative—qualities of the spine and legs. The various stabilizing and corrective operations, the large assortment of casts and splints, and the voluminous studies on posture and balance point to this.

Is it possible that we do not pay sufficient attention to the first half of the above word? Do we neglect the subject of weight in our patients? If not, then we have written mighty little about it. Most textbooks are absolutely silent; a few make allusions. In 1931 I read a paper on "Diet and Orthopaedic Surgery" before the combined State Medical Associations of the Dakotas. As far as I know, it is the first article on this trite subject. No doubt our Program Committee had this in mind when it asked me to present a similar subject today.

Fat causes orthopaedic trouble in two ways:

(*a*). By its presence in excess within a joint,—as Hoffa fat knee (numerically a small group).

(*b*). By contributing to excessive body weight and thus throwing pathological strain on sick, maimed, and weakened weight-bearing organs (numerically a very large group).

The Hoffa Fat Knee.—Proper weight-reducing diet has, in our hands, caused excessive intra-articular fat to disappear. This often obviates operative surgery as advised and practised today. We have had nine cases in which relief was obtained and operation avoided. The most characteristic case may be cited in a few words:

CASE REPORT

H. S., female, twenty-five years old, a teacher, was sister of a prominent internist.

Diagnosis: Bilateral "Hoffa fat knee". Was unable to walk over one and a half hours daily (the balance of the day having been spent in a chair).

Chief symptoms: Pain on use; mild swelling; indefinite locking of both knees.

Reduction of weight (twenty-five pounds) resulted in absorption of excessive intra-articular fat. Now is well, attends to her duties, and plays tennis expertly. (This observation dates back to 1912.)

* Read before the Annual Meeting of the American Orthopaedic Association, at Toronto, Canada, June 17, 1932.

Two homely incidents again called my attention to this subject some ten years ago:

(*a*). The gun, which actually weighed eight pounds, but seemed fifty pounds heavy at the end of the day's hunting.

(*b*). The immense annual bodily relief felt on changing from the heavy "winter" fur overcoat to the topcoat of spring.

From the foregoing facts I drew two conclusions and have acted upon them since:

(*a*). If prolonged excessive weight-bearing will tire normal individuals, what will it not do to defective human carrying apparatus?

(*b*). The actual amount of excessive weight need not be large,—often ten or fifteen extra pounds may cause trouble and their removal might give relief.

The Spine.—We believe that excessive weight in itself may be the cause of many backaches. We always attempt to bring the weight to normal (for height and age) in the following conditions: lumbo-sacral strain, spondylolisthesis, round shoulders, and postural defects. In adult scoliosis which is causing pain, this method has spared several of our patients a fusion operation.

The Hip.—A painful, senile arthritic hip in a heavy man often becomes comfortable from weight reduction alone. Some of our most grateful patients belong to this class. We have also successfully availed ourselves of this method in old unreduced congenital bilateral hip dislocations and in cases of old Legg-Perthes' disease and coxa plana which were painful. The underlying pathology is, of course, not changed at all, but the superincumbent overload is removed. If pain persists, we can always operate on the joint later. Our patient will have become a much better surgical risk by the weight reduction.

The Knee.—Chronic unilateral and bilateral arthritis from whatever cause in the later adult years offers a fruitful field. Occasionally weight reduction alone totally removes all subjective symptoms. While we, of course, as a rule avail ourselves of other therapeutic measures (chiefly physiotherapy and splinting), we have a small series of cases in which the desired relief of knee symptoms was obtained by the sole use of the restricted diet.

The Foot.—We find that the most frequent use we make of this method is in foot conditions (weak foot and metatarsalgia). It is a valuable and indispensable adjunct of treatment even if weight excess seems small (ten to fifteen pounds). We have arrived at a point where we refuse further treatment if the patient does not cooperate. We feel that proper shoes, arches, and exercises do not have a fair chance if the overload is permitted to remain.

Infantile Paralysis.—Excess weight should be prevented in this chronic condition. If it is present, it should be gotten rid of. Manifestly the atrophied legs and returning muscles should not be required to function under more than the physiological load. It is probable that not

the least of the benefits of the swimming pool is that it stimulates metabolism and thus helps to keep the patient's weight within reasonable limits.

Fractures—(three considerations):

(*a*). The obese are poor fracture risks when viewed from any angle. It is good fracture prophylaxis for all of us to remain thin and supple—(Much could be made of this theme).

(*b*). Fresh fractures. In heavy, fat, adult individuals, we begin a reducing diet from the onset of treatment. We believe it to be good therapy not to demand too much of the recently healed weight-bearing bone.

(*c*). The old malunited fracture of hip, knee, ankle, or foot often becomes comfortable on removal of the overload. In our practice numerous patients have thus avoided operative interventions. (This is especially true in people over fifty.)

Nothing will be said about the method of weight reduction. This is a rather long story which has been well told by many There are many good books on the subject. We have never used thyroid extract or any other drug as an aid to weight reduction. We fear it. We never allow a patient to lose more than two or three pounds per week. Many patients become over eager to lose weight rapidly. This enthusiasm needs checking. Other patients are obstreperous or lazy. No results are to be expected among them. When the desired weight loss exceeds fifty pounds, we call on the internist to act as referee in the struggle between the patient and his own fat.

CONCLUSIONS

(*a*). Consideration of a proper reducing diet has become, in our work, of daily necessity and occurrence and of practical value.

(*b*). A chronically painful joint or series of joints of the spine or lower extremity often ceases to be troublesome in an individual who has been overweight and who, by means of a reducing diet, has brought his weight to normal.

(*c*). The amount of overweight need not be large,—occasionally the removal of ten or fifteen pounds is enough to spell the difference between comfort or pain in a given case.

(*d*). This method in proper cases is an adjunct to other forms of treatment used in orthopaedic surgery.

REPORT OF A CASE OF UNUSUAL INJURY TO THE FOREARM

BY PENELOPE SHERWOOD, M.D., NEWBURGH, N. Y.

The following case is reported because of its unusual character.

Patient—H. McN., aged eighteen, white, male—was referred to the writer September 9, 1930, by Dr. C. E. Fallon of Newburgh, New York.

About eight weeks previous, *i.e.*, in July, 1930, the patient, while employed in a fabrikoid factory, caught his left arm in a roll of cloth as it was being wound tightly on rollers, the arm being drawn in up to the elbow. No acute pain was experienced at the time. The patient was seen immediately by the company physician, Dr. Fallon. The arm presented a marked degree of posterior bowing of both radius and ulna, together with fixation in position of supination, a condition which had not been present two days previously when Dr. Fallon had given the patient the physical examination required before employment.

An x-ray (Figs. 1 and 2) revealed a partial epiphyseal separation of the left radius and ulna with no displacement, with a disturbance of the relations of radius and ulna at the wrist joint, the distal end of the ulna being more nearly on the level with that of the radius than is found normally.

The arm was splinted for three weeks, then the patient resumed work for one week but had to desist on account of pain in wrist and forearm. There had been no improvement under daily massage and baking, and the arm was still in supination.

Physical examination on September 9, 1930, gave the following findings:

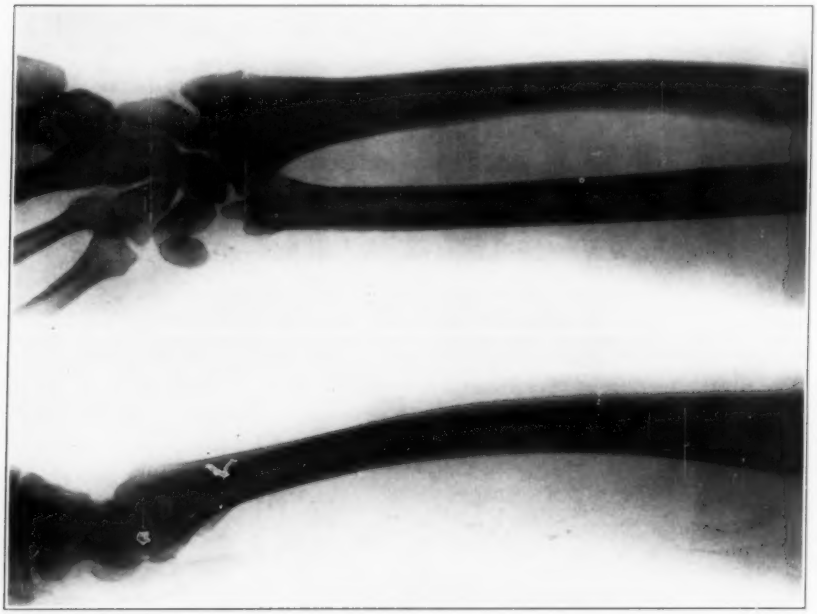

FIG. 1

Left radius and ulna, August 1, 1930, following injury. Note the abnormal amount of bowing of the bones as compared with that in the right arm.

Physical examination was negative except for the left forearm which showed:

Distinct bowing of both bones (convexity dorsal).

Elbow, wrist, and fingers showed full range of motion.

Strength of grip in left hand only one-third that of right.

All muscle groups apparently active.

The forearm was in full supination with less than five degrees' active pronation.

Passive pronation could be accomplished to about twenty-five per cent. of the normal range.

Further attempt to pronate caused pain in wrist, on palmar surface.

There was no swelling, but patient stated that, on flexing the fingers, the hand felt "swollen".

Diagnosis was made of traumatic deformity of radius and ulna. X-ray (Fig. 3) showed healing of epiphyseal injury, with no bony block to pronation, but with the marked bowing of the radius and ulna.

TREATMENT

Two weeks of baking, massage, and vigorous passive and active motion accomplished little in regard to active pronation, and there was an increase in throbbing pain in arm and hand.

October 22, 1930, an osteotomy of the left radius and ulna was performed through two incisions at the apex of the bow. On reduction of the bowing, the arm could be pronated easily beyond neutral. After closure of the wound, a cast was applied from the axilla to the base of the fingers, with the forearm in a position half-way between neutral and full pronation. Postoperative x-ray (Fig. 4) showed the osteotomy with the fragments in good apposition, a restoration of the normal curve of the radius and ulna, as well as of the relation of the two bones at the wrist joint. The bone was extremely hard, which makes it surprising that so much bowing could have occurred without fracture.

Convalescence was uneventful aside from a somewhat slow formation of sufficient callus. The stitches were removed after ten days, and at three weeks the cast was bivalved and light massage and active motion begun.

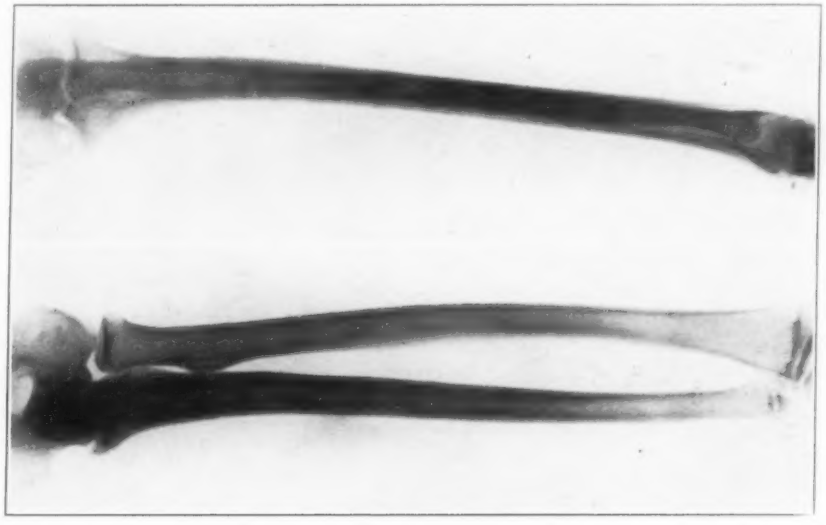

FIG. 2

Right radius and ulna, October 22, 1930.

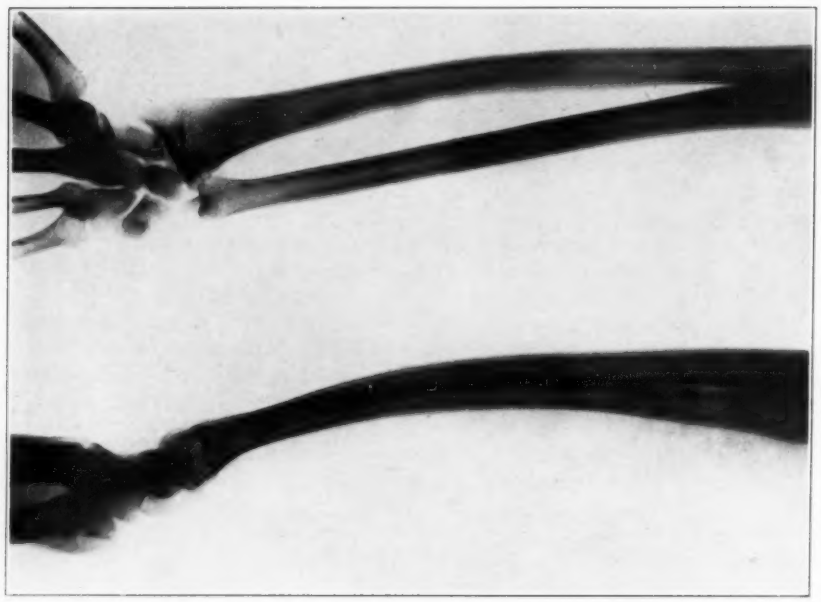

FIG. 3

Left radius and ulna, October 22, 1930, just before osteotomy.

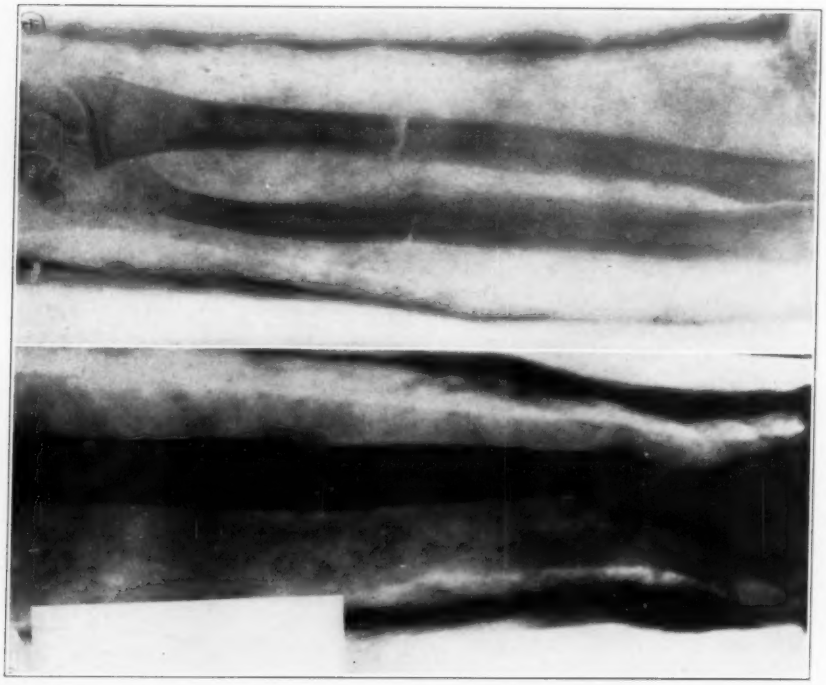

Fig. 4

Left radius and ulna, October 23, 1930, showing correction of deformity.

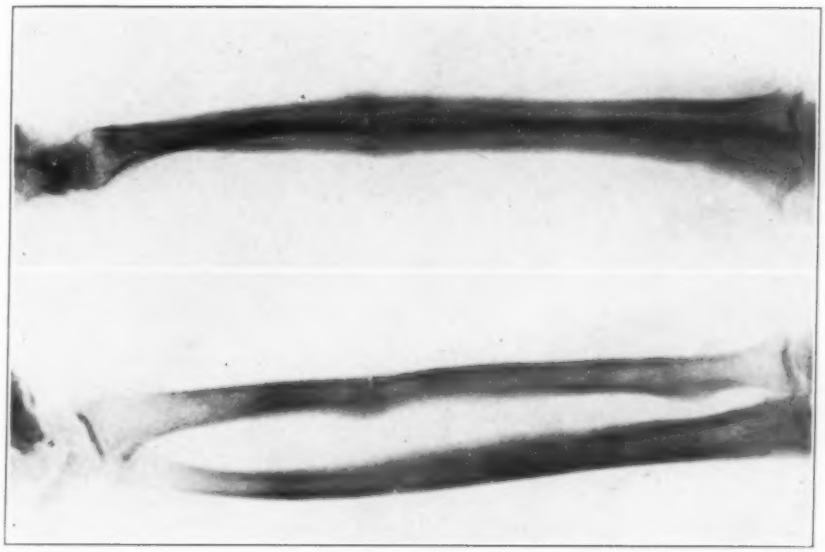

FIG. 5

Left radius and ulna, January 4, 1931, three months postoperative.

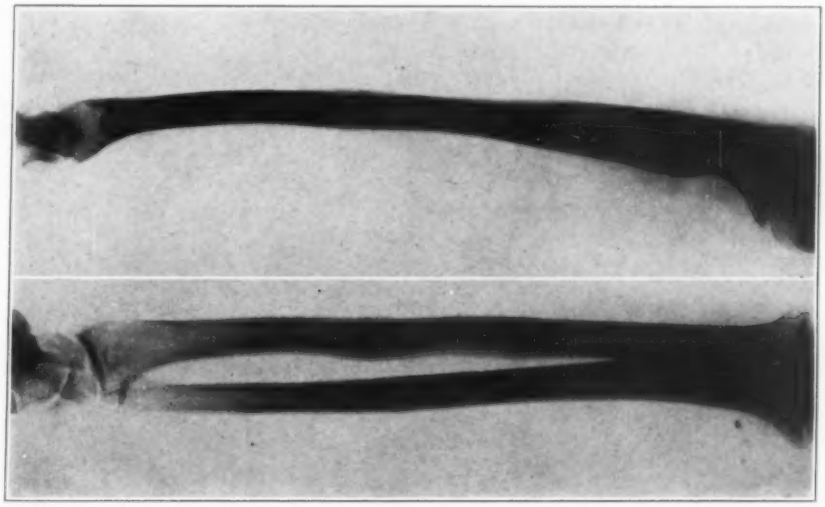

FIG. 6

Left radius and ulna, May 20, 1931, seven months postoperative.

Twelve weeks after operation, all support was removed. By March 14, 1931, (five months postoperative), the x-ray showed complete healing of the osteotomy, and the arm showed: full pronation and supination, no abnormal bowing, no pain nor tenderness; numbness in thumb which followed operation was practically gone; strength in grip of hand was ninety per cent. normal.

The final examination on May 16, 1931, showed the same findings as in March, except for an increase in the strength of the hand to normal.

SECTION OF THE FLEXOR TENDONS OF THE MIDDLE FINGER OF THE LEFT HAND THROUGH A PALMAR WOUND. PRIMARY SUTURE AND CURE

BY ANTHONY ANDREASEN, M.R.C.S., KINGSTON HILL, ENGLAND

Madame X was admitted to the hospital July 27, 1931, suffering from a palmar wound, following a fall upon a bottle. She had been to her own doctor who had done his best to clean the wound and had sent her to the hospital.

On examination four hours after the injury, a contused jagged wound three centimeters long was found, extending from the inferior border of the annular ligament of the wrist across the palm and the fold formed by opposition of the thumb. Flexion of the middle finger was impossible. No nerve lesion could be demonstrated. Hemorrhage had been abundant but had stopped. A diagnosis of section of the deep and superficial flexor tendons of the middle finger alone was made. Infection of the wound was, of course, almost certain in view of the first effort to clean the wound. However, immediate intervention was decided upon.

Morphin was administered to the patient. The arm was then raised above the level of the shoulder and an Esmarch bandage applied from the elbow down towards the wrist in such a way as to make the flexor tendons come down towards their distal severed extremities.

Anaesthesia was produced by an injection of ten cubic centimeters of five-tenths per cent. novocain around the median and ulnar nerves at the level of the radial and ulnar styloid processes, and was completed by a ring of subcutaneous injection around the wrist at the same level.

Disinfection of the wound was then carefully carried out,—*i.e.*, block resection of the contused edges and enlargement of the wound in its long axis to give more space in which to work. The superficial palmar arch was then displayed and sectioned between double ligatures. The two extremities of the superficial flexor tendon were easily recognized, but the ends of the deep flexor were located with difficulty, owing to the marked involvement of the lumbricales of the second and third spaces. As these were torn and contused, they were resected as high up as possible and the greater part of them removed. When the ends of the deep flexor were finally brought into view, their mangled condition required removal of nearly five-tenths centimeter of each.

The tendon suture was performed with No. 0 forty-day chromic gut. Two separate sutures of catgut united the subaponeurotic cellular tissue. The palmar aponeurosis was sutured with three fine catgut stitches and the skin drawn together gently with fine fishing gut, the whole wound being closed without drainage.

The dressing applied consisted of a large piece of roll gauze in the palm with quantities of wool over it, and a bandage. A dorsal plaster-of-Paris frame was then applied in order to keep the fingers and wrist in flexion.

After the operation there was no pain and no rise of temperature above 99 degrees. The dressing was renewed on the eighth day and the stitches removed. The suture line was slightly reddened. On the fourteenth day the posterior plaster gutter was removed and the wound looked firm and healthy; a new dressing was applied. Gentle and progressive movements were started and the patient left the hospital in very good condition.

At present her hand shows: flexion of the first and second phalanges of the middle finger, normal; flexion of the third phalanx, slightly limited; the lateral movements of the fingers, normal; palmar scar, soft and non-adherent; no loss of sensibility or other evidence of nerve lesion. Muscular power is normal.

The patient now having full use of her hand, it seemed that a note of the case and the reason for resection of the lumbricales would perhaps

be of interest, since it is to that procedure that success in the case is attributed.

This case report is of interest for the following reasons:

1. Some authors state that suture should be primary as in the above case; others prefer secondary suture. This case would seem to uphold the teaching of the first group.

2. The way in which the Esmarch bandage was applied is well enough known to avoid need of comment.

3. The anaesthesia is of importance. The nerve-block anaesthesia employed is easy to use and is extremely efficient. It is essential to allow ten to fifteen minutes to secure complete anaesthesia.

4. The lumbricales of the second and third spaces were resected. Most authors mention injury of the lumbricales associated with tendon lesions, and their importance in the propagation of infection, but none give any opinions on the matter of resection. In view, therefore, of the contused state of the muscles, and the fact that their cicatrization would only tend to fix the tendons to the surrounding structures, resection was performed. This procedure also gave more room in which to work.

Bloch and Tailhefer suggest resection of the superficial flexor tendons to allow suture of the deep flexors, but so much damage seems unnecessary when simple resection of the lumbricales gives even more room.

The objections one might raise to the procedure are:

1. That it is impossible to resect the lumbricales without involving the synovial sheaths of the tendons.

2. That the lumbricales are important in the physiology of the hand.

American surgeons would preserve the serous sheaths at all costs, while Leriche contests that it is necessary to extirpate them. The author believes that, as in the case of all traumatized serous membranes, they will, if left, only cause adhesions and bands, and so hinder a complete recovery.

In reply to the second objection, the lumbricales are not in the true sense autonomic muscles; they have no true long insertion and in function they only reenforce the interosseus muscles.

REFERENCES

1 Dujarier, C. et Bourguignon: Rupture du Tendon du Long Fléchisseur du Pouce. Greffe Tendineuse. Guérison. Bull. et Mém. Soc. Nat. de Chir., LIII, 532, 1927.

2. Bloch, J. C., et Tailhefer, A.: Contribution à l'Étude de la Réparation des Tendons Fléchisseurs des Doigts. Gaz. d. Hôp., CII, 5, Jan. 2, 1929.

3. Bloch, J. J., et Bonnet, P.: Evolution et Traitement des Plaies des Tendons de la Main. XXXVIII Congrès de l'Association Française de Chirurgie, p. 547, 1929.

A CASE OF HEMANGIECTATIC HEMIHYPERTROPHY WITH SUBJECTIVE SYMPTOMS OF SACRO-ILIAC DISTURBANCE DUE TO ABNORMAL BONY DEVELOPMENT

BY J. E. M. THOMSON, A.B., M.D., LINCOLN, NEBRASKA

Though anomalies of development are rare, particularly those in which one or more of the extremities develops out of proportion to the others, they cause distressing and unfortunate disabling phenomena that manifest themselves not only in their determent of function but also as an unsightly stigma upon the patient, often contributing to mental manifestations of abnormal nature.

Wakefield[1], in 1926, in reporting a case of terminal hypertrophy of the left shoulder girdle, arm, and hand, with naevus and varicose veins, gives a very satisfactory historical résumé of the cases in the literature. The earliest case he found was one reported by Wagner[2] in Germany in 1887; Osler[3] found twelve cases in a review of all the literature up to 1889. However, in 1897, Le Blanc[4] collected seventy-eight cases. Gesell[5] collected forty cases in 1921. From these various series Wakefield accounted for one hundred and ninety-five cases, forty-four of which were total hemihypertrophies.

Since Wakefield's article at least ten other cases have been reported in the literature. These conditions appear under various names but are usually associated with increased blood supply and the hypertrophied extremities or parts of the body, with various degrees of increased pigmentation and reddening of the entire or part of the extremity or trunk.

Among the more recent cases is that of a child, aged seven, recorded by Paterson and Wyllie[6], with increased growth of the right leg and with surface temperature apparently higher than the left; pigmentation and dilated blood vessels present about the knee and shin. Their opinion was that the abnormal growth could be explained by the increased vascularity at least at the knee joint and the growing end of the tibia and fibula.

Susman and McCredie[7] reported a case of a girl, fifteen years of age, whose enlargement of the arm was of only six months' duration, and they gave to this condition the term "haemangiectatic hypertrophy", and thought perhaps the condition could be accounted for by an old venous thrombosis.

Beatty[8] reports a girl with swelling of the veins of the left arm and increased length of the limb with evidence of not only dilated vessels and increased temperature but cutaneous angiomata.

Harris and Wright[9] showed a boy, aged ten, whose history dated back to a recognition of the hypertrophy of the right leg in early life. The pigmented patch on his leg had recently ulcerated. There was four and one-half centimeters of difference in the length of the extremities. This

led them to experimental work to determine whether increase in blood supply was totally responsible for an increase in the length of the bone. They destroyed the sympathetic innervation to the forelimbs of a group of kittens, thereby increasing the blood supply to the forward extremities. Rather confusing results were obtained, but their deductions led them to believe that the increased blood supply, due to liberating the vasoconstrictions, in itself would not result in hypertrophy and increase in bony length of the extremities.

Cannon[16] and others at Harvard performed similar experiments and found no increase in growth of length of the limb after unilateral sympathectomies. One explanation is that perhaps the vessels supplying nutrition to bones have no opportunity to dilate within their bony canals, even when the sympathetic vasoconstrictors are released, thereby not permitting increase of blood supply to the bone structure. About the same status of opinion exists in regard to the lack of dilatation of arteriosclerosis vessels after release of the vasoconstrictor mechanism. For under such circumstances the hardening changes in the vessel walls make dilatation impossible.

It has long been recognized that a chronic passive congestion, when it is due to a chronic inflammatory process, particularly in the region of the knee, will cause an increased growth in length of the extremity. With such a process there is an increase in vascular supply, due to an actual increase in blood vessels within the inflammatory lesion. It would, therefore, seem reasonable to assume that, in those congenital cases of hemihypertrophy with increase in length of an extremity, there must be an increase in number of blood vessels within the bones involved, in a relative proportion to the evidence of increase in the peripheral blood supply, and evidence of hemangiomata.

The case of Susman and McCredie, with the history of an acquired hypertrophy as the result of an attack of thrombosis, would substantiate this explanation, as the hypertrophy directly followed an inflammatory process with increase of vascular tissue.

The writer wishes to add another case to those reported in the literature.

A young woman, aged thirty-three, was first seen at our clinic August 3, 1920. She came in complaining of bilateral hallux valgus and flat feet, sacro-iliac pain, and an increase in the length of the left lower extremity. At that time her bunions were removed and she was given a sacro-iliac brace to wear. The possibility of shortening the left leg was discussed. She made an uneventful recovery from her bunion operation, but after the period of hospitalization again complained of pain in the lower part of the back. Finally a diagnosis of sacro-iliac arthritis was tentatively made and treatment instituted in that direction. Temporary relief was obtained by a brace. She disappeared from the clinic and, in February 1923, she came back directly under the writer's care on account of painful pronated feet and low back pain.

A careful history brought out the fact that she had had an extensive erysipelas extending over the trunk at the age of nine, and a similar attack three years later. Since her last visit she had drifted from one to another of the leading (and otherwise considered) clinics throughout the country, receiving all manner of treatment and advice, without getting relief from the pain in the sacro-iliac region. The left lower extremity

was almost two inches longer than the right. The circumference of the left thigh was two and one-half inches larger than the right, and the left leg, one and one-half inches larger than the right. The left foot was extremely pronated and apparently there was very marked muscular weakness. It seemed evident that, if the left lower extremity were shortened to equal the right, the correction of her posture would very likely relieve the sacro-iliac strain from which she continuously suffered. Such radical surgery she would not consider. As an immediate palliative procedure the heel of the left side was lowered, the heel raised on the right side, thereby compensating to a certain extent for the difference in length of the extremities, and corrective apparatus for the pronation was applied to the shoes. Finally, in October, 1924, the femur was shortened and the length of the legs equalized. During the year following she was kept under observation, but continuously complained of the low back pain in the left side. Again she disappeared to visit more clinics and to receive more treatments of various kinds; finally she reappeared in December, 1930, with the report of having suffered more or less continuously with pain in the left sacro-iliac joint.

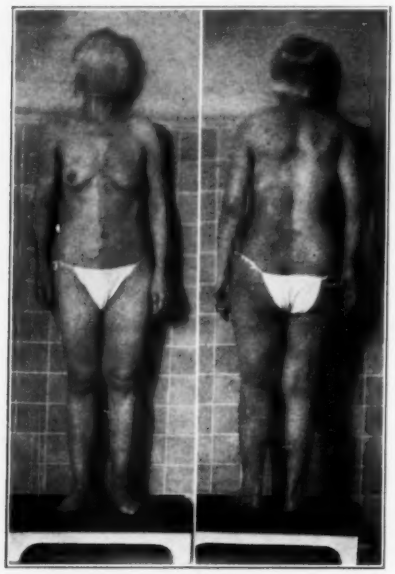

FIG. 1

The left side of the entire body (head, neck and lower arm excepted) is a dark wine color. The left thigh and leg are distinctly larger than the right. The left thigh is shorter and the knee higher than the right, due to operative shortening of the extremity. The left arm is longer and larger than the right.

More x-rays were taken. There was no evidence of sacro-iliac disease or other abnormality not noted in previous examinations. These x-rays showed an unusual bony development of the left ilium, a deeper, larger, more rounded left pelvic outlet; the head, neck and shaft of the left femur were of virtually the same diameter. The mid-shaft showed healed evidence of the shortening operation. The photographic illustration of her body showed the generalized wine-red color of the pigmentation on the left side of the body which extended from the neck to the toes. It seemed to absolutely bisect the trunk, fading out in the upper part of the upper extremity. The legs were of about equal length but the left leg was considerably larger in circumference than the right, about two and a half inches at the thigh, and one and one-half inches at the calf. The left upper extremity was one and one-fourth inches longer than the right. The left arm was one-half inch larger than the right; the forearms were equal. The feet apparently had fairly well compensated for their deficiency and caused her little or no difficulty when proper shoes were worn. She had a rather moody disposition; one might consider her peculiar and eccentric, but no definite mental derangement was exhibited. Probably the recognition of her unilateral development and pigmentation were responsible for these eccentricities. The only explanation of the extreme discomfort she complained of was the possibility that, since an inequality in length of the extremities had been corrected, there was still an inequality in the development of the sacro-iliac joints. In other words, the ilium articulation might have increased in proportion beyond that of the sacrum, or the inequality of the two sides of the pelvis had instituted an incompensable postural asymmetry responsible for unusual movement in the left sacro-iliac joint, causing the painful symptoms complained of.

The patient was advised of the possibilities offered in a sacro-iliac fusion for relief of her discomfort. She readily acquiesced and as a last resort, on December 17, 1930, the

operation was performed after the method described by Smith-Petersen. She was placed in a double plaster-of-Paris spica cast which was removed at the end of six weeks and a sacro-iliac belt was applied. She was allowed to leave the hospital at the end of nine weeks with little or no discomfort or pain. Her convalescence has been entirely uneventful. The pain and discomfort so long complained of have entirely disappeared, thereby substantiating the assumption that a pelvic unbalance, with abnormal left sacro-iliac function, was responsible for her symptoms.

The symptoms and physical manifestations of hemangiectatic hemihypertrophy of this case are essentially different from most of those reported in that there was such pronounced disability and discomfort, due to the increase in length of the left lower extremity and also to abnormal development of the left side of the pelvis, principally of the ilium.

This unusual case is reported because of the interesting objective physical phenomena exhibited and the particularly aggravating, long-standing, painful symptoms of low back pain that did not respond to equalization of length of the extremities, but did respond to rest in bed and partially to the wearing of a pelvic brace, only to reappear with activity of the patient or the laying aside of the brace. Later the brace lost much of its effectiveness, and ultimately a fusion of the left sacro-iliac joint brought relief of symptoms.

FIG. 2

X-ray of pelvis. There is a very much larger and abnormally developed ilium on the left. The left pelvic outlet is distinctly different from the right and has a more rounded appearance. The head, neck, and diameter of the femora are about equal.

BIBLIOGRAPHY

1. Wakefield, E. G.: Hypertrophy, Congenital, of the Left Shoulder Girdle, Arm and Hand, with Naevus and Varicose Veins. Am. J. Med. Sciences, CLXXI, 569, 1926.
2. Wagner, P.: Zur Casuistik des Angeborenen und Erworbenen Riesenwuchses. Deutche Ztschr. f. Chir., XXVI, 281, 1887.
3. Osler, W.: A Case of Congenital and Progressive Hypertrophy of the Right Upper Extremity. J. Anat. and Physiol. (London), XIV, 10, 1879–80.
4. LeBlanc, E.: Contribution à l'Étude de l'Hypertrophie Congénitale, Unilaterale, Partielle ou Complete. Paris, Henri Jouve, 1897.
5. Gesell, A.: Hemihypertrophy and Mental Defect. Arch. Neurol. and Psychiat., VI, 400, 1921.
6. Paterson, D., and Wyllie, W. G.: Hypertrophy of the Bones of a Limb Due to a Naevus. British J. Child. Dis., XXII, 36, 1925.
7. Susman, Eric, and McCredie, D. W.: Haemangiectatic Hypertrophy of the Arm: A Case of Genuine Phlebectasis. Med. J. Australia, II, 581, 1927.
8. Beatty, C. C.: Haemangiectatic Hypertrophy of the Arm. Proc. Roy. Soc. Med., Sec. Study Dis. Child., XX, 532, 1926–27.
9. Harris, K. E., and Wright, G. Payling: A Case of Haemangiectatic Hypertrophy of a Limb and Observations upon Rate of Growth in the Presence of Increased Blood Supply. Heart, XV, 141, 1930.
10. Wakefield, E. G.: Congenital Hypertrophy, Involving the Right Side of a Female Aged Six. Ann. Int. Med., I, 292, 1927.
11. Ougrélidzé, M.: Hémihypertrophie Congénitale Droite Stridor Laryngé Congénital. Nourrisson, XVI, 40, 1928.
12. McFarland, B. L.: Hemihypertrophy. British Med. J., I, 345, 1928.

OSTEOGENIC SARCOMA IN CHILD OF THREE YEARS

BY A. L. CRAIG, M.D., F.A.C.S., HONOLULU, T. H.

Shriners' Hospital, Honolulu

The following case is presented as interesting from the standpoint of diagnosis as well as treatment. The report emphasizes the necessity of tissue section even in a child of three years.

History. E. N., an Hawaiian, aged three years. A small Hawaiian girl, very anaemic and appearing acutely ill, entered the out-patient clinic on the morning of May 4, 1931.

The general physical examination was essentially negative except for a large fungating mass over the anterior aspect of the right tibia. When the dressing was removed, the wound bled very freely and it was necessary to use pressure bandage to control hemorrhage.

Blood tests showed:

White blood count—6,700.

Hemoglobin—45 per cent.

Red blood count—3,685,000.

Wassermann and Kahn tests were made and later reported as negative.

Family history. Father, aged thirty-eight, is living and well; mother, dead; three brothers, aged five, six, and seven, and a sister, aged two, are living and well.

Clinical history. This child was admitted to the Kauikiolani Children's Hospital on November 24, 1930, with a history of slight pain and tenderness over the tibial tuberosity on the right leg. Temperature 99.6 degrees. White blood count 8,600. X-rays showed a destructive process involving the upper end of the tibia on the right side.

On November 24, 1930, the area was opened and curetted. Cultures taken at the

FIG. 1

MAY 4, 1931.

FIG. 2
NOVEMBER 24, 1930.

FIG. 3
DECEMBER 1, 1930.

FIG. 4
MAY 4, 1931.

FIG. 5
MAY 12, 1931.

time of the operation were negative. Child was discharged from the hospital on December 3, 1930.

On February 3, 1931, she was again admitted to the Children's Hospital. Temperature was 100.2 degrees and white blood count was 8,700. X-rays taken showed some extension of the process. On February 4, 1931, the area was again curetted out. Cultures taken at the time of this operation were also negative.

FIG. 6
JUNE 2, 1931.

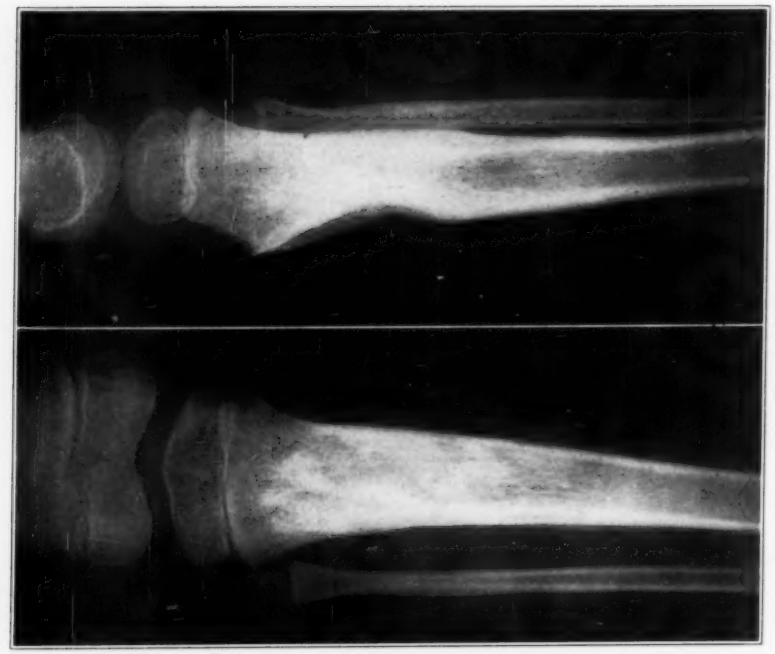

FIG. 8
NOVEMBER 15, 1931.

FIG. 7
JUNE 24, 1931.

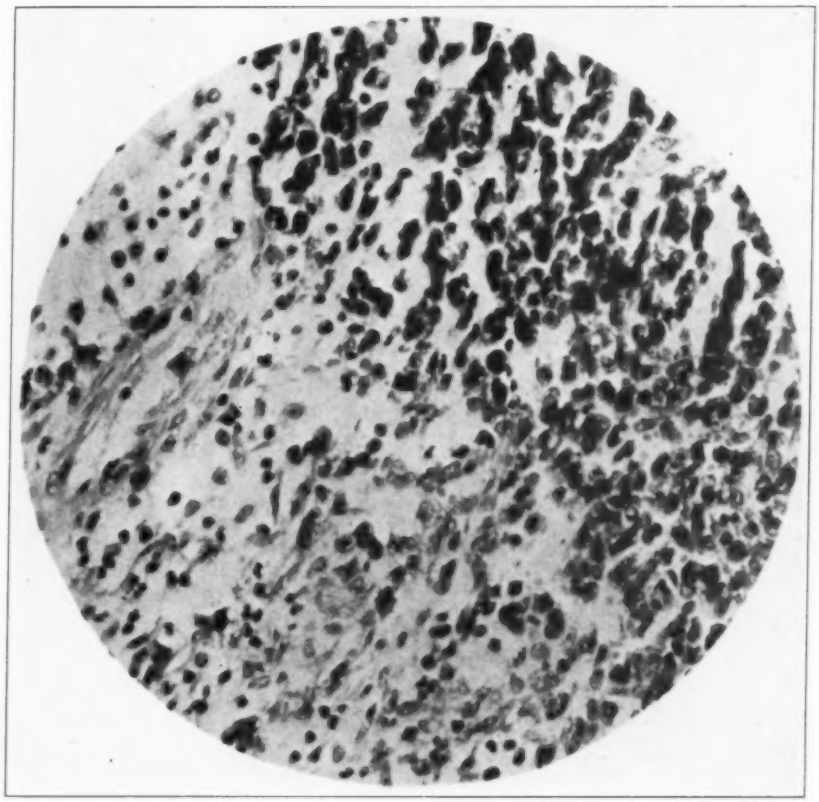

FIG. 9

The child was admitted to the Shriners' Hospital on May 4, 1931, for observation and biopsy.

On May 10, 1931, the section was returned with a diagnosis of osteogenic sarcoma.

On May 21, 1931, 2,000 milligram-hours of radium was applied to the wound. In a few days, the hemorrhage had subsided and the mass was very much smaller.

The child was discharged to her home, but reported back on June 2, 1931, when 2,000 milligram-hours of radium was again applied and, on July 2, 1931, when 3,000 milligram-hours was applied.

Present condition. At the present time the child has gained ten pounds, the mass has entirely healed, and x-rays of the chest and other long bones are negative. It is yet too early to draw any conclusions, but at present the child has no external manifestation or x-ray evidence of an extension of the growth. She is reporting at regular intervals to the clinic, and will continue to do so during the next two years.

AN ANALYSIS OF PRIVATE ORTHOPAEDIC PRACTICE

BY RICHMOND STEPHENS, M.D., NEW YORK, N. Y.

The following statistical report has been prepared to answer questions often propounded by surgeons who are considering entering the field of orthopaedic surgery. It is based on 400 clinical records taken from alphabetically filed closed cases and not any picked group. These cases were all in a private practice in a city of approximately 50,000 population, with about eighty practising physicians, and give a very fair idea of the types of cases encountered and show the source of reference. In larger cities, an orthopaedic practice would vary as so frequently men confine their work more to one definite line,—such as consulting, operating, or industrial surgery.

No consideration has been given to financial matters—such as the percentage of collections—as that is too variable with general conditions, local conditions, and the individual.

Age Groups	
Under 1 year	17
1 to 5 years	44
6 to 15 years	48
16 to 50 years	241
51 to 70 years	45
Over 70 years	5
Total	400

Source of Reference	
From doctors	254
Through other patients	77
From nurses	9
Through local hospital	17
From social-service agencies	14
Sent by insurance companies	15
Referred by lawyers	3
Referred by chiropodists	5
Referred by druggist	1
Referred by osteopath	1
Called without reference	4
Total	400

Miscellaneous Statistics

Patients who came to office once only, for consultation or examination	132
Hospital consultations	23
Hospital operations without after-care	10
Hospital operations and after-care	27
Consultations at patients' homes	4
Consultations at homes with later office treatment	3
Compensation-insurance cases	61
Cases in which court or compensation hearings were attended	4
Braces applied, other than foot supports	30
Foot cases seen and treated	77
Patients who received physiotherapy in some form	101
Non-orthopaedic conditions seen and referred to other doctors	12

DIAGNOSES

Fractures and dislocations		78
Fracture of skull	1	
Fracture of clavicle	3	
Fracture of ribs	1	
Fracture of pelvis	1	
Fracture of humerus	4	
Fracture of elbow	2	
Fracture of forearm	2	
Fracture of wrist and hand	16	
Fracture of neck of femur	4	
Fracture of shaft of femur	6	
Fracture of leg	14	
Fracture of os calcis	2	
Old fracture of spine	8	
Old dislocation of shoulder	1	
Old fracture of elbow	4	
Non-union of ulna	1	
Compound, tibia and fibula	5	
Old fracture of ankle	2	
Dislocation of astragalus	1	
Back pain including trauma		27
Shoulder pain including trauma		16
Knee-joint injuries		23
Sprained ankle		4
Contusions		5
Old hematoma		1
Coccygodynia		3
Spondylolisthesis		3
Bursitis of knee		2
Bursitis of elbow		3
Tenosynovitis of wrist		1
Loose cartilage in elbow		1
Acute pyogenic knee		1
Cellulitis of foot		1
Adherent tendo achillis		1
Osteomyelitis of femur		1
Osteomyelitis of tibia		1
Exostoses		2
Lipoma		1
Myositis ossificans		1
Snapping jaw		1
Charcot wrist		1
Congenital hypertrophy of leg		1
Fragilitas ossium		1
Paget's disease		1
Dupuytren's contracture		2
Volkmann's ischaemic paralysis		1
Musculospiral paralysis		2
Deltoid paralysis		1
Bell's facial paralysis		1
Hemiplegia in adults		3
Brachial birth paralysis		7
Spina bifida		1
Anterior poliomyelitis		12

Scoliosis		13
Deformities of rachitis		9
Congenital torticollis		3
Congenital club-foot		6
Congenital dislocation of hip		2
Foot disabilities		107
Perthes' disease		1
Tuberculosis		8
Spine	1	
Hip	1	
Knee	4	
Ankle	1	
Wrist	1	
Chronic arthritis		28
Multiple	8	
Spine	4	
Hip	4	
Knee	12	
Non-orthopaedic cases (referred elsewhere)		12
Diabetic gangrene	2	
Dermatitis of foot	1	
Sarcoma of ilium	1	
Carcinoma of ischium	1	
Gout	1	
Hernia	2	
Fat ankles	1	
Sinuses of buttocks	1	
Oedema of legs	1	
Oedema of arm after breast amputation	1	

AN ORTHOPAEDIC LEVER FOR CORRECTING DEFORMITIES OF THE FOOT

BY FREDERICK F. KORTLUCKE, B.SC., M.B., CH.B., EDINBURGH, SCOTLAND

The use of Thomas's key wrench is widely practised by orthopaedic surgeons, but many must have experienced a relative degree of inefficiency when the instrument is employed in certain conditions. The principal difficulty arises when the instrument is applied to the small misshapen foot in such a condition as a congenital talipes equinovarus. The coapting parallel surfaces of the wrench are not the best mechanical means of securing the parts, and in order to overcome this difficulty the operator may be led to apply such a degree of force as unduly to traumatize the included tissues.

Many attempts have been made to modify the Thomas wrench and to overcome its disadvantages, and other appliances based on different principles have been devised. No one instrument of the many described in the literature has been as useful as the Thomas wrench in correcting all foot deformities, nor has any overcome all the dangers associated with manipulation, the Thomas wrench being the worst offender. In the Thomas wrench two parallel planes approximate one another on an irregular surface; hence when force is applied it is transmitted to *two points*. All the usual instruments fit the foot poorly, slip when needed to grip most firmly, are cumbersome to use, and are for the most part expensive.

The writer has lately had an opportunity of working at this question, and has devised an instrument which has proved efficient, without incurring the risk of unduly traumatizing the related tissues. The problem was to devise a simple, practical, easily controllable, inexpensive instrument, which would at once fit the foot, minimize trauma, rest securely, and perform all the necessary manipulations. The instrument here described seems to meet these requirements. It is a lever modified to fit the foot by means of an adjustable belt. The lever is a tubular bar of metal or wood twenty inches long, one and one-half inches broad, and three-quarters of an inch thick, having two transverse slots (one and one-fourth by five-eighths inches), *A* and *B*, respectively, four and ten inches from one end.

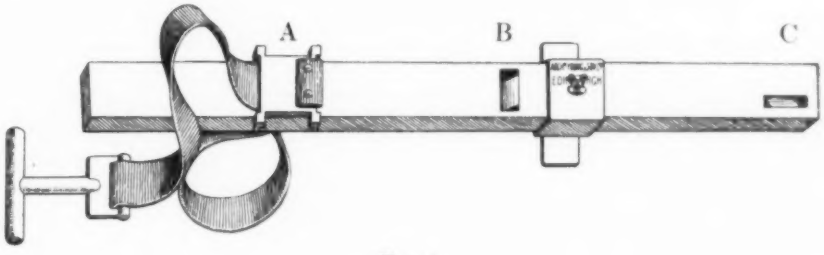

FIG. 1

The edges of the instrument are rounded, not as shown in figure.

A third slot (*C*) lies in the axis of the bar three-eighths of an inch from the other end. These slots perforate the bar at an angle of thirty degrees. The part which grips the foot is a strong webbed belt twenty inches long by one and one-eighth inches wide, with a T-shaped grip at one end, and a specially devised buckle at the other. The third part is a metatarsal bar three and one-half inches wide, which slides on the lever as a collar, and is capable of being fixed at any distance by means of a thumbscrew. The mechanics of the instrument are illustrated in Figure 2. The belt

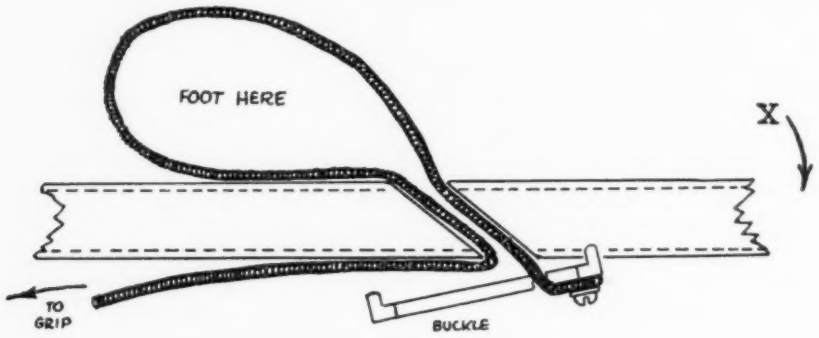

FIG. 2

is doubled on itself through a transverse slit with buckle and hand grip on the underside of the lever; the strap is then tightened around the foot by pulling on the hand grip in the axis of the lever. When pressure is exerted at *X* the buckle is pulled against the belt, which describes a sharp angle, so that the loop cannot slip while pressure is maintained.

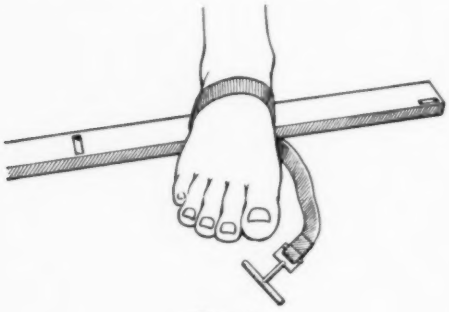

FIG. 3

The other diagrams show the application of the lever in correcting the various deformities in talipes equinovarus. Figure 3 shows the method of correcting the inversion. It is noted that the central aperture (*B*) is used, so that one hand grips each end of the bar, thus carefully controlling the amount of force applied; also that the belt goes over the point where the main deformity exists,—*viz.*, the midtarsal joint. To make the most complete use of the force applied, care must be exercised to keep the lever in the same plane as the strap. When the lever is kept parallel to the leg while adjusting the strap, the strap fits the curves of the foot most closely, and the lever automatically adapts itself to the plantar surface of the foot.

Figures 4 and 5 show the method of correcting the calcaneal inversion. Transverse slit *A* is used here so that the short end of the lever rests di-

rectly on the calcaneum. One hand is sufficient to manipulate the lever, leaving the other free to hold the ankle.

Figure 6 illustrates the method of correcting the equinus deformity. In this case the longitudinal slit *C* is used for the strap and the heads of the metatarsals allowed to rest on the metatarsal bar.

Once the operator is conversant with the use of the instrument he will easily see how other foot deformities, such as pes calcaneus, flat-foot, etc., can be corrected.

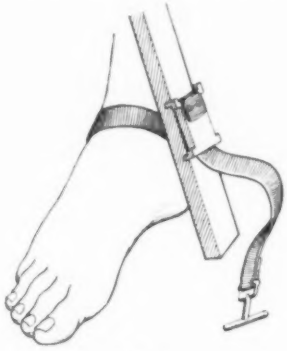

FIG. 4

FIG. 5

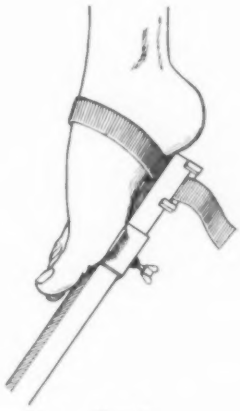

FIG. 6

The instrument is as simple as a lever, and is as easily controlled. That it fits the foot and applies the force where most needed is obvious, for a *band* of force has been substituted for two *points* of force, and if a Bier's bandage is placed about the foot, not even the tender scarf skin of an infant is abraded. With such accurate apposition and control, unnecessary trauma has been eliminated.

Although the advantages of this lever are apparent, it is not suggested that it should be used as a substitute for early manual manipulation, which is preferable to any instrumental procedure, but it will be found of great value in infants as an adjuvant in gripping securely the small malformed foot. The instrument will probably be of most use in those cases of neglected and particularly recalcitrant club-foot of youth; it cannot be expected to be of much advantage where osteotomy is indicated because of the bony changes.

The writer desires to thank Prof. John Fraser of the Royal Infirmary, Edinburgh, for his interest in the apparatus. His enthusiasm was stimulating, his suggestions and the opportunities he gave for applying the lever were of incalculable assistance.

A NEW HIP REST FOR THE APPLICATION OF PLASTER-OF-PARIS SPICAS OR JACKETS IN PRONE OR SUPINE POSITIONS*

BY NATHAN H. RACHLIN, M.D., BROOKLYN, NEW YORK

While applying hip spicas, we have found that the patients almost invariably show evidence of discomfort to a greater or lesser degree; they shift positions to relieve themselves of pain, so that frequently they slide upward, resting on the upper part of the thighs, which are now necessarily flexed somewhat on the pelvis, with the pelvis and lumbar spine unsupported, slumping backward. This results in a cast improperly applied and that under difficulties.

In studying the causes thereof, we have observed that all the standard rests made—the separate rests as well as those on the fracture tables—are of a flat design and constructed near the perineal rod, so that when the patient is placed upon it, he necessarily rests on the tip of his spine, with the lumbar spine unsupported, and the weight of almost the whole body gravitating upon it.

It is an undeniable law of physics, that when a convex body is placed upon a flat surface, the entire weight will be on the crest of the convexity, no matter how large the underlying flat surface may be.

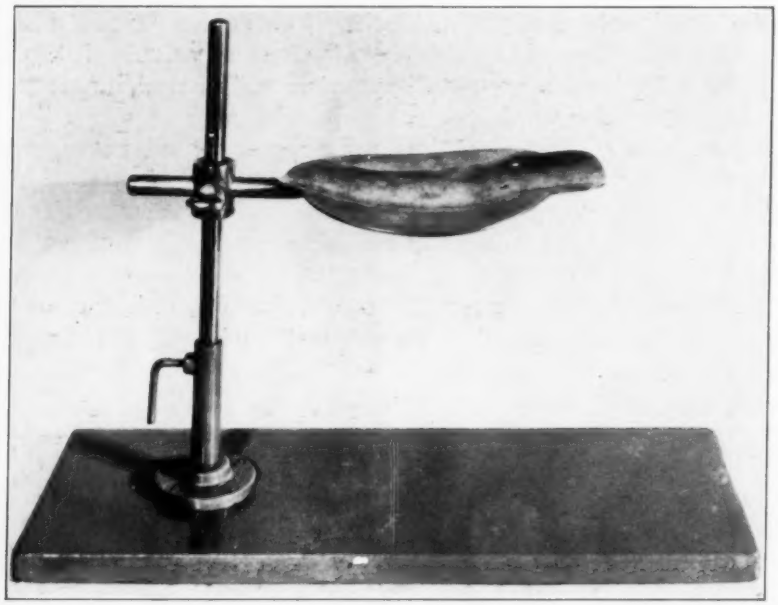

FIG. 1

Separate hip rest to be used on a table or at bedside.

* From the Orthopaedic Services of Kings County, Beth Moses, and Neurological Hospitals.

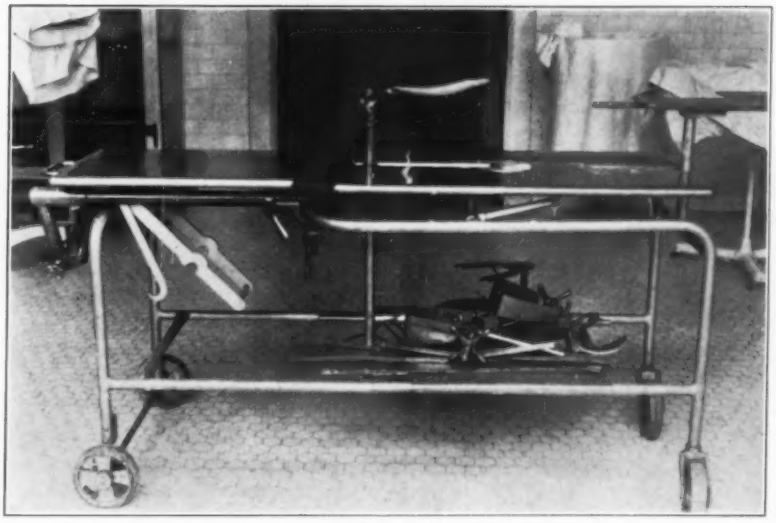

FIG. 2
Hip rest attached to fracture table.

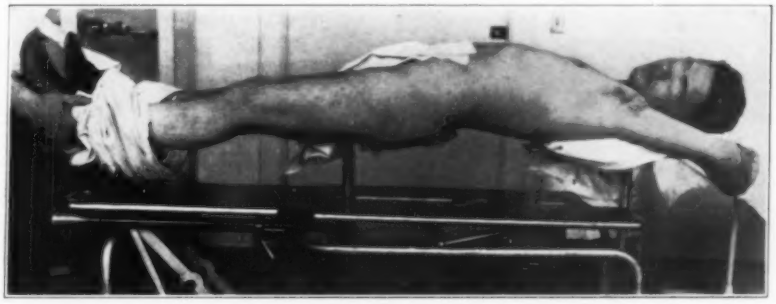

FIG. 3
Patient in position for application of cast in supine position.

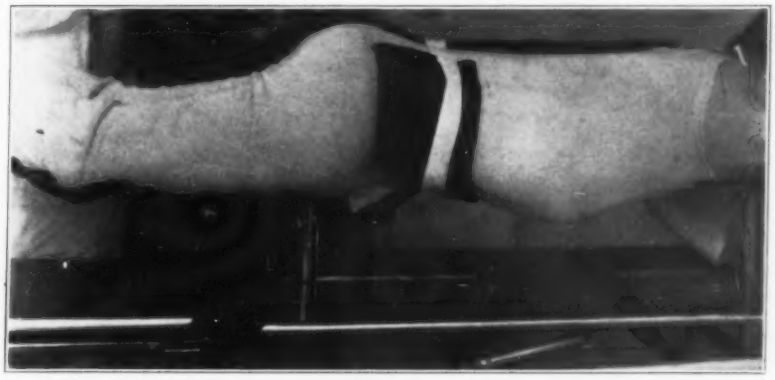

FIG. 4
Patient in position for application of cast in prone position.

In the matter under our consideration, under such circumstances, the whole weight is borne by the lower end of the spine, resting on a flat, hard, non-giving, metallic support. Moreover, since in most of these cases we are dealing with individuals who are suffering from some disease or injury that is already more or less painful, the amount of discomfort evinced by these patients is not surprising.

The normal resting parts of the lower end of the body are the gluteal regions and the tuberosities of the ischii, with the spine slightly raised between these supports, so that little or no pressure is ordinarily exerted on it.

Bearing in mind the anatomical structures of the pelvis, the support

FIG. 5

FIG 6

Figs. 3, 4, 5, and 6 show a patient weighing about 200 pounds, suffering from pseudohypertrophic muscular dystrophy, who was fitted with a plaster corset without any discomfort after an unsuccessful attempt by the suspension method.

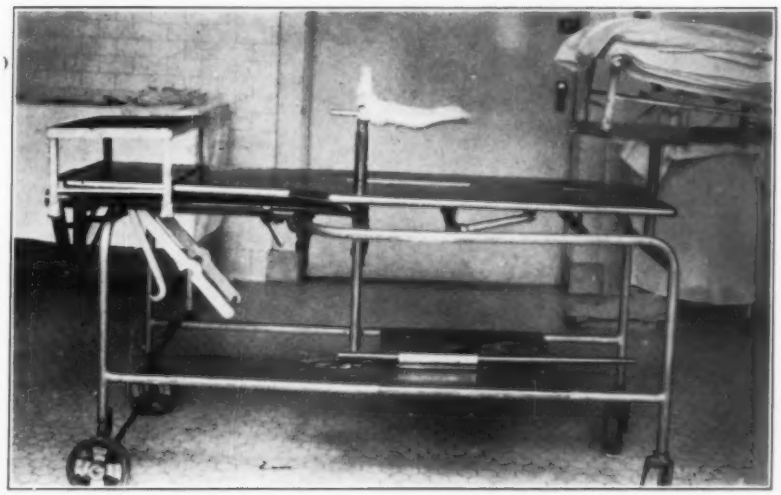

FIG. 7

Table in position for application of a jacket in a hyperextended position in fracture of the spine.

here illustrated has been devised. It conforms structurally to the shape of the sacrum, is grooved in the center for the spine so that no pressure is put upon it, and is so constructed that it can be moved upward or downward toward the perineal rod to conform to the size and shape of the in-

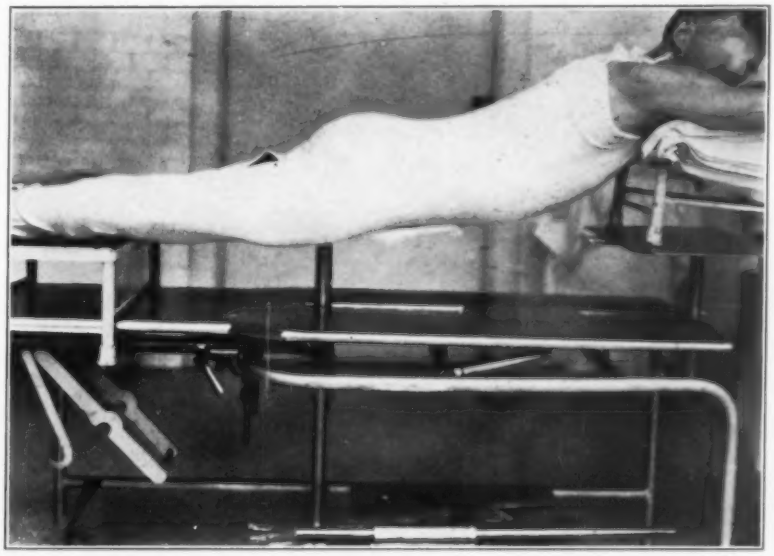

FIG. 8

Patient in position for the application of jacket in fracture of spine. Note the generalized hyperextension of spine, the degree of which can be regulated by the height of the shoulder support; also the comfort of the patient while in that position.

dividual. At its upper end there is a flange curving forward, which supports the lumbar spine in its normal physiological position: lordosis.

The patients thus placed are absolutely at rest, fully relaxed; and the lumbar spine is properly supported. The cast can now be applied with ease and without haste.

During the five years in which this apparatus has been in use, it has been found so satisfactory that the writer has discarded entirely the suspension method, finding the recumbent position more comfortable and more efficient. The support is so arranged that it will fit readily into any standard fracture table or can be used at the bedside on its own base.

In spinal corrective work, by changing the position of the upper part of the body and by exerting pressure on the required points, and with the other means at our disposal, the jacket can be applied to correct or improve the structural changes present in functional scoliosis when temporary use of the jacket or corset seems advisable. In applying the jacket in a prone position, it is possible to obtain complete correction of any existing deformity. In structural scoliosis in the same position, a greater degree of correction is obtained by molding the plaster while setting. In vertebral compression fractures or dislocations, by placing the patient in extreme hyperextension with chest elevated and the arms outstretched, and by pulling on an elevated object for further traction, one can use corrective force to reduce the dislocated vertebra or to separate the compressed body, and the patient can be immobilized without further disturbance in such a position.

THE ROLLER SKATE AS AN AID TO ACTIVE MOTION AND MUSCLE TRAINING IN CASES OF POLIOMYELITIS

BY NATHAN H. RACHLIN, M.D., BROOKLYN, NEW YORK

In cases where the muscles involved are of insufficient strength to enable them to move the limb, or in very young children who cannot be made to understand what they are expected to do, the writer has been able to get the cooperation of these patients by the use of a roller skate, and thus obtain the full benefit derived from active motion, which is of prime importance in the treatment of this malady.

Thus, to illustrate, by attaching the skate on the inner side of the leg, with the knee flexed and patient lying on opposite side, the thigh can be swung back and forth in a horizontal plane, with a minimum amount of effort, thus overcoming gravity as well as the retarding effect of the bedclothes.

In a similar manner, by adjusting the skate to other parts of the limb in the line of the muscle pull, the same effect can be produced elsewhere, as for quadriceps and hamstring action on inner aspect of the foot, etc.

The advantages of this method are:

1. The ability to utilize a select group of muscles in a very weak state.
2. Ready and active cooperation by patients and parents.
3. Continuous and uninterrupted home treatment under supervision of nurse or parents.

News Notes

The Forty-sixth Annual Meeting of the American Orthopaedic Association was held in Toronto, June 14 to 18, under the presidency of Dr. W. E. Gallie. Mr. G. R. Girdlestone of Oxford was present as foreign guest and contributed a paper to the meeting.

The morning of the first day was occupied by clinical demonstrations of interesting cases by Dr. Gallie and his associates. The afternoon was open for the members and guests to occupy themselves at will.

On the remaining days, the following program was presented:

JUNE 16

Symposium on Arthritis:

Production of Chronic Arthritis by Injection of Weak Acids, Distilled Water, and Normal Saline.
Dr. J. Albert Key, St. Louis, Missouri.

Clinical Experimental Observations with Regard to the Injection of Certain Agents (Pregle Solution) into Chronic Arthritic Joints.
Dr. J. E. M. Thomson, Lincoln, Nebraska.

Certain Arthritic Disturbances in Parathyroid Disease.
Dr. Robert D. Funston, Detroit, Michigan.

The Physiology and Pathology of Joint Effusions.
Dr. Walter Bauer, Boston, Massachusetts (by invitation).

Orthopaedic Treatment in Spondylitis of the Strümpell-Marie Type.
Dr. Loring T. Swaim, Boston, Massachusetts.

The Influence of Diet in Cause and Treatment of Chronic Arthritis.
Dr. A. Almon Fletcher, Toronto, Canada (by invitation).

The Future of Orthopaedic Surgery with Especial Reference to Teaching.
Dr. David Silver, Pittsburgh, Pennsylvania.

Hyperparathyroidism and the Accompanying Bone Change.
Dr. Max Ballin, Detroit, Michigan (by invitation).

Arthrodesis of the Tuberculous Hip.
Dr. John C. Wilson, Los Angeles, California.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Amputation Stumps of the Lower Extremity—Surgical Technique and Sites of Election.
Major N. T. Kirk, Washington, D. C.

Fracture of the Femoral Neck, Statistics and Motion Pictures—Modification of Whitman Technique.
Dr. G. W. Leadbetter, Washington, D. C.

JUNE 17

The President's Address.
Dr. W. E. Gallie, Toronto, Canada.

The Treatment of Fractures in the Light of Their Ischaemic Complications.
Mr. G. R. Girdlestone, Oxford, England (by invitation).

Alcoholization of Peripheral Motor Nerves of the Legs in Spastic Paralysis of Childhood.
Dr. Ralph R. Fitch, Rochester, New York.

Operative Arrestment of Longitudinal Growth of Bones in the Treatment of Deformities.
Dr. D. B. Phemister, Chicago, Illinois.
The Treatment of Compound Fractures, a Specific Technique for Prevention and Control of Osteomyelitis.
Dr. Fraser Gurd, Montreal, Canada (by invitation).
The Use of Bacteriophage for Osteomyelitis.
Dr. Fred H. Albee, New York City.
Crippledom and Reducing Diet.
Dr. Emil S. Geist, Minneapolis, Minnesota.
Some Biologic Effects of Light.
Prof. Brian O'Brien, Rochester, New York (by invitation).
Congenital Non-Union of the Tibia.
Dr. Wallace H. Cole, St. Paul, Minnesota.
Congenital Metatarsus Varus.
Dr. Charles W. Peabody, Detroit, Michigan.
The Relation of the Abdominal Muscles to Scoliosis.
Dr. C. L. Lowman, Los Angeles, California.
Bone Block for Paralytic Foot-Drop.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

JUNE 18

The Nucleus Pulposus:

(*a*) Embryology, Anatomy, and Physiology.
(*b*) Clinical and Experimental Studies.
Dr. E. L. Compere, Chicago, Illinois (by invitation).
Dr. D. C. Keyes, Chicago, Illinois (by invitation).
Methods of Measuring the Internal Pressure of the Intervertebral Disc.
Dr. Charles K. Petter, Minneapolis, Minnesota (by invitation).
Correction of Compressed and Impacted Fractures of the Spine.
Dr. John Dunlop, Pasadena, California.
Dr. Carl H. Parker, Pasadena, California.
Old Dislocations at the Shoulder and Presentation of a New Instrument.
Dr. William Arthur Clark, Pasadena, California.
Fractures of the Femur in Children from a Functional Standpoint.
Dr. C. F. Eikenbary, Seattle, Washington.
Malunion and Non-Union in Fractures of Long Bones.
Dr. W. W. Plummer, Buffalo, New York.

At the last Executive Session of the Association, held Saturday following the final session, nine orthopaedic surgeons were elected to membership:

Samuel R. Cunningham, M.D., Oklahoma City, Oklahoma.
Joseph Freiburg, M.D., Cincinnati, Ohio.
Carl T. Harris, M.D., Rochester, New York.
Myron O. Henry, M.D., Minneapolis, Minnesota.
Arthur Krida, M.D., New York City.
Merrill K. Lindsay, M.D., New Haven, Connecticut.
Joseph I. Mitchell, M.D., Memphis, Tennessee.
Barclay W. Moffatt, M.D., New York City.
Rudolph S. Reich, M.D., Cleveland, Ohio.

And the following were elected Corresponding Members of the Association:

Mr. G. R. Girdlestone, Oxford, England.
Prof. A. Mouchet, Paris, France.
Prof. G. A. Wollenberg, Berlin, Germany.

The following officers were elected for the ensuing year:

President: Arthur Steindler, M.D., Iowa City, Iowa.
President-Elect: Melvin S. Henderson, M.D., Rochester, Minnesota.
Vice-President: Robert Soutter, M.D., Boston, Massachusetts.
Treasurer: John L. Porter, M.D., Evanston, Illinois.
Secretary: DeForest P. Willard, M.D., Philadelphia, Pennsylvania.
Executive Committee: W. E. Gallie, M.D., Toronto, Canada.
Membership Committee: James A. Speed, M.D., Memphis, Tennessee.
Program Committee: A. R. Shands, Jr., M.D., Durham, North Carolina.

Delegates to American College of Surgeons: Dr. William B. Owen, Dr. D. B. Phemister, and Dr. David Silver.

Delegates to the Congress of the German Orthopaedic Association: Dr. Arthur Steindler and Dr. E. G. Brackett.

The next meeting of the Association will be held in Washington, under the presidency of Dr. Arthur Steindler.

The Association received with regret the news of the death of Dr. Arthur H. Cilley.

ARTHUR H. CILLEY

Dr. Arthur H. Cilley, a member of the American Orthopaedic Association, died in New York City on May 31, 1932, at the age of sixty-two. He was also a Fellow of the American College of Surgeons and the New York Academy of Medicine. Dr. Cilley received an A.B. degree from Princeton University in 1893 and the degree of M.D. from the College of Physicians and Surgeons, Columbia University, in 1896. After completing a two-year internship at the New York Post-Graduate Hospital and one year at the Hospital for the Ruptured and Crippled, he practised orthopaedic surgery in New York City. He served with merit in the recent World War. At the time of his death he was Assistant Clinical Professor of Surgery and Associate Attending Orthopaedic Surgeon at the New York Hospital and the Cornell University Medical College Association. During the past eighteen years he has been a valuable teacher in the Orthopaedic Department and Chief of the Clinic at Cornell. He is survived by his wife and one son.

A one-day meeting of the **British Orthopaedic Association** will be held in London on Wednesday, July 27, 1932, preceding the sectional meetings of the British Medical Association.

In recognition of the twenty-fifth anniversary of the founding of the **Hospital for Joint Diseases,** New York City, a Clinical Week was held at the hospital April 15–21. A program of unusual interest was presented.

Dr. John Heberling has been appointed assistant orthopaedic surgeon to the Home for Crippled Children in Pittsburgh.

The Congress of the **Yugoslavian Orthopaedic Society** and of the **Czechoslovakian Orthopaedic Society** will be held in Zagreb, Yugoslavia, on October 3 and 4, 1932. The principal topics for discussion will be: "The Social Importance of Orthopaedic Surgery", "Tuberculosis of the Bones and Joints", "Rickets", and "Poliomyelitis". Further information about the Congress may be secured from the President, Prof. Božidar Spišič, Palmotičova 22, Zagreb, Yugoslavia.

Dr. Mayer S. DeRoy has been appointed assistant orthopaedic surgeon on the staff of the Montefiore Hospital, Pittsburgh.

The International Congress on Biliary Disease will meet at Vichy, France, September 19–22, 1932. Information about the Congress may be obtained from Dr. Frank Smithies, 920 North Michigan Avenue, Chicago.

Tumors, benign and malignant, will be the theme of the 1932 Graduate Fortnight of **The New York Academy of Medicine** which will be held October 17–28 inclusive. The medical profession of the country is invited to attend and to participate in the Graduate Fortnight. A complete program and registration blanks may be secured by addressing The New York Academy of Medicine, 2 East 103rd Street, New York City.

A most cordial invitation has been extended to the members of the American Orthopaedic Association to attend the **Twenty-Seventh Congress of the Deutsche Orthopädische Gesellschaft,** which is to be held in Mannheim on September 5, 6, and 7, under the presidency of Prof. Adolf Stoffel. The first day will be devoted to the consideration of "The Pathophysiology and Treatment of Fracture of the Neck of the Femur", and the second day to "Internal Injuries of the Knee Joint". Both of these subjects will also be considered with reference to industrial surgery. The afternoon of the second day will be given up to a discussion of "Plastic Surgery of the Acetabulum". The subject for the third day will be "Malunion of Fractures".

The next Congress of the **International Society of Orthopaedic Surgery** will be held in London, July 19–22, 1933. The following have recently been elected to membership in the Society:

Dr. Z. B. Adams, Boston, Massachusetts.
Dr. George E. Bennett, Baltimore, Maryland.
Dr. Frank D. Dickson, Kansas City, Missouri.
Dr. Emil S. Geist, Minneapolis, Minnesota.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Dr. Ellis W. Jones, Los Angeles, California.
Dr. Leo Mayer, New York City.
Dr. Charles Ogilvy, New York City.
Dr. H. Winnett Orr, Lincoln, Nebraska.
Dr. J. Torrance Rugh, Philadelphia, Pennsylvania.
Dr. Edwin W. Ryerson, Chicago, Illinois.
Dr. Robert Soutter, Boston, Massachusetts.
Dr. Walter G. Stern, Cleveland, Ohio.
Dr. Arthur Steindler, Iowa City, Iowa.
Dr. Philip D. Wilson, Boston, Massachusetts.

At the meeting of the **Chicago Orthopaedic Club** held on April 8 at Cook County Hospital, the program was in charge of the Orthopaedic Staff. Interesting cases were presented and papers read by Dr. Philip Lewin, Dr. Daniel Levinthal, Dr. E. J. Berkheiser, Dr. Philip Kreuscher, Dr. Marcus H. Hobart, and Dr. Arthur Conley.

At the Spring Meeting of the **British Orthopaedic Association** in Nottingham on Friday and Saturday, April 22 and 23, a large series of cases was demonstrated by Mr. Crooks and Mr. Malkin at the General Hospital and at the Harlow Wood Orthopaedic Hospital, and three clinical problems were discussed:

I. Suppurative Arthritis of the Hip

Mr. Crooks, Nottingham, presented a series of twelve cases of pyogenic infection of the hip joint. Early drainage was necessary not only to save life, but to minimize epiphyseal destruction. The classical route for drainage was by a posterior incision, but in half of the cases abscesses pointed in front of the joint and an anterior incision had been used. After operation the limb was fixed in abduction, and traction was maintained to prevent pathological dislocation. There was no mortality, and the end result in eight of the twelve cases had been a stable hip. In infants there was usually destruction of the epiphysis and of the neck of the femur, and frequently an unstable dislocation was inevitable.

Mr. Aitken, London, advised a short spica and not a calliper as an ambulatory splint. In unstable cases the ring of the calliper pushed the neck of the femur out of the acetabulum and aggravated the tendency to dislocation. He felt that operative stabilization should be performed when the patient was fourteen or fifteen years of age by constructing a new roof over the upper end of the femur.

Mr. Elmslie, London, doubted whether any attempt at operative stabilization was of value. The only measure he would advise was a bifurcation osteotomy and, although this stabilized the limb satisfactorily, it had the serious disadvantage of increasing the shortening. The best end result which could be secured was a bony ankylosis in good position.

II. Dislocation of the Patella

Mr. Malkin, Nottingham, reported seven cases of outward dislocation of the patella. In five cases the displacement was habitual and of congenital origin, and in two cases recurrent. Normally, in consequence of the erect posture of man, the oblique axis of the quadriceps maintained an angle with the vertical axis of the patellar ligament, and favored outward displacement of the patella. This was still further exaggerated if knock-knee was present. Successful treatment demanded not only replacement of the patella, but realignment of the quadriceps with the patellar ligament; in congenital cases it was necessary to dissect and free the vastus externus, and in all cases it was advisable to displace the tubercle of the tibia inward and downward. The downward displacement compensated for underdevelopment of the external condyle of the femur. If knock-knee was present, an osteotomy to correct it was essential, but the correction could be more easily secured in congenital cases by deferring osteotomy until after replacement of the patella and realignment of the quadriceps The operation which he had learned from Mr. Elmslie, had been performed in six cases. After several years there had been no recurrence of the dislocation, and a normal range of knee movement was restored.

Mr. Elmslie said that the important features of his operation were: (*a*), dissection and replacement of the vastus externus; (*b*), displacement of the tubercle of the tibia inward and downward; (*c*), transference of a pedicle of joint capsule from the inner to the outer side; (*d*), the construction of a flap of capsule to hold the rectus femoris inward.

Mr. Fairbank, London, said that osteotomy of the femur was always necessary in habitual dislocation, but not always in recurrent dislocation of the patella. He had frequently noticed in recurrent dislocation that, although there might be no genu valgum with the knee extended, this deformity was evident when the knee was flexed.

III. Fractures of the Spine

Mr. Crooks, Nottingham, reported forty-four recent cases of fracture of the spine. The mortality was twenty-five per cent., and in almost fifty per cent. of the cases the spinal cord had been injured. Reduction of the fracture was advocated, and emphasis

was laid on the ill effect of allowing patients to lie in bed for several weeks without active treatment. In such circumstances functional complications commonly appeared, and energetic exercises in the gymnasium were necessary to combat phthisis. Twelve cases were demonstrated of crush fractures of the spine which had not been seen until several weeks after the accident, so that a slight kyphotic deformity remained. Although good movements were restored, only one of the twelve was free from pain and only two had resumed work.

Mr. Hope Carlton, London, said that the results of treatment of crush fractures of the spine had been greatly improved since the introduction of the technique described by Watson Jones, but he had found difficulty in some cases in correcting the last few degrees of wedging of the vertebrae.

Mr. Cochrane, Edinburgh, said that he had used Watson Jones' technique in reducing fractures of the spine, but in two cases paralytic ileus had arisen, and he attributed this to the hyperextension, and the lack of abdominal support during reduction. The use of a ventral hammock assisted in preventing this.

Mr. Watson Jones, Liverpool, drew attention to the constancy with which pain persisted, if the wedging of the crushed vertebrae was not corrected. Records were now available of over fifty fractures of the spine which had been reduced by his method, and, provided that the deformity was fully corrected and recurrence prevented by the wearing of a plaster jacket for a sufficiently long period, there was no pain, and fully seventy-five per cent. of the patients resumed heavy work. Consolidation of fractured vertebrae was slow, and the plaster jacket should be retained in simple crush fractures for four months and in extensively comminuted fractures for six months. Energetic exercises could be practised throughout this time and in uncomplicated cases recumbency was not necessary for more than a few days. Paralytic ileus might arise in any case where a plaster jacket was applied under anaesthesia, and was due not to the hyperextension, but to the anaesthetic and too liberal administration of morphin. No anaesthetic should be used.

Mr. Bankart, London, emphasized the necessity for immediate reduction. The pain of an unreduced crush fracture of the spine could only be relieved by operative fusion of the affected area with a bone graft. The best treatment for fractures of the lumbar transverse processes was to ignore the fracture and treat the case as a simple muscle injury, in order to avoid functional complications and to prevent adhesion formation.

Mr. Trethowan, London, said that persistent chronic backache was inevitable if crush fractures of the lumbar spine were not reduced. Since the pain was due to malalignment of the spine, he doubted whether bone grafting would always relieve it.

Mr. Naughton Dunn, Birmingham, advocated temporary splintage of the spine in order to decide whether bone grafting would be successful or not. Operative treatment could only succeed in those cases where pain was controlled by wearing a spinal support.

At an informal meeting held at the **Liverpool Medical Institution** on March 21, Dr. Jean Macnamara, who was introduced by Sir Robert Jones, gave an address on acute poliomyelitis.

The history of the treatment of infantile paralysis by human immune serum was reviewed, and the experimental basis for the therapy outlined. The succession of epidemics which had occurred in Melbourne during the years 1927 to 1931 had given an opportunity for recognition of cases before paralysis, and therefore for the treatment of cases at the stage at which serum was effective. During the first year in which serum was available, of 135 cases, only one was diagnosed before paralysis had developed; in 1931, of 270 cases, eighty-six were diagnosed and treated in the preparalytic stage.

The "dromedary type" of onset, in which the two phases of the disease were separated by an interval of apparent recovery, had been frequently observed, but more often three or four days of definite illness had preceded paralysis. The symptoms were de-

scribed as general and special. The general symptoms of fever, vomiting, constipation and headache did not differentiate from other diseases, but, in the cases which progressed to the stage of paralysis, other symptoms served as warning signals,—such as, tremor of the hands, photophobia, and retention of urine. The most important sign had been the "spine sign",—a disinclination for forward flexion of the spine owing to the pain involved. In older children this sign was elicited by placing a coin on the knee and bribing the child to attempt to bend forward toward it. In infants the sign was elicited by passive flexion.

The necessity for a careful general examination, and for constant watchfulness—particularly in times of epidemics—of patients suffering from an indefinite illness was stressed, in order that confirmation of the clinical diagnosis should be sought at the first appearance of warning signs and symptoms, by examination of the cerebrospinal fluid. The changes in the fluid were an increase of polymorphonuclear cells, then of lymphocytes, and later of globulin content. The estimation of the chlorid content was useful in discriminating between poliomyelitis and tuberculous meningitis.

Clinical experience in 1928 had confirmed the warning of experimental work of the danger of delay between the removal of cerebrospinal fluid and administration of serum. The procedure adopted in Victoria of examining the cerebrospinal fluid at the bedside, while the lumbar puncture needle, with obturator replaced, remained *in situ*, was described. It was important to reexamine the patient twelve to eighteen hours later, for, if the first intravenous and intrathecal injection of serum was adequate to establish a passive immunity, there should be marked improvement in the general condition and a rapid fall of temperature.

The details of the method of preparation adopted by the Commonwealth Serum Laboratories in Melbourne were given. The product fulfilled the requirements of a serum, free from hemolysis, aseptic without added antiseptic, and as free of fibrinogen as possible.

The experience in Melbourne had been parallel to that of other countries where serum had been used. The use of human immune serum in the preparalytic stage of poliomyelitis had been proved beneficial by the low mortality rate, the low average total paralysis, and the strikingly low proportion of paralysis of the severer grades. The results of treatment of 133 cases in the preparalytic stage had been as follows: in sixty-six no paralysis could be detected; in sixty paresis for some weeks could be demonstrated by careful examination, but cleared up completely with no residual paralysis; in seven treatment failed, one case proving fatal and six developing paralysis. The seven failures had taught two lessons:

A. Delay between the withdrawal of fluid and the administration of serum must be avoided (this was the probable explanation of the fatal case and of three with paralysis).

B. An adequate initial intrathecal and intravenous dose was essential, and, if the response in eighteen to twenty-four hours was unsatisfactory, a second injection of serum should be given.

Dr. Macnamara then referred to the other aspect of the treatment of acute poliomyelitis, where advice was not sought until paralysis had fully developed. In 1925, when an attempt was made to secure adequate after-treatment for every paralyzed patient, the principles which had been enunciated by Sir Robert Jones and Robert Lovett were used as the basis for the work. The patient was placed on a frame of a modified double Thomas pattern with, in addition, foot pieces, head piece, and, if necessary, arm pieces. A cloth corset had been used for abdominal paralysis. When there was involvement of the small muscles of the hand, a papier-mâché splint was applied. So long as hyperaesthesia persisted, the treatment involved complete rest on the frame, with daily immersion in hypertonic saline baths, at first for ten to twenty minutes and later for longer periods. Even during immersion, care was taken to prevent stretching of paralyzed muscles.

Reeducation was commenced when the hyperaesthesia subsided, and as far as possible this was carried out by experts. Experience in Melbourne confirmed Lovett's conclusion, that the degree of recovery which could be achieved by an expert was three times as great as that achieved by well-meaning amateurs. An accurate knowledge of the anatomy and actions of muscles was essential to prevent the development of trick movements. Furthermore, considerable experience was necessary to assess the fatigue point of the neuromuscular system which was being coaxed back to normal function. Splintage required constant supervision, and frequent modification of the position of the limb was necessary in order to give the advantage of relaxation to groups of muscles relatively weaker than their antagonists.

The principle taught by Jones and Lovett, that the greatest factor in converting a slight paresis of muscle, which is capable of recovery, into severe and permanent paralysis is fatigue, had been borne out by experience in the Physiotherapy Department of the Children's Hospital in Melbourne. For this reason when the lower limb, abdominal, or spinal muscles had been paralyzed, an endeavor was made to continue rest by splinting in recumbency with muscle reeducation, as long as any recovery was evident. The treatment was not changed until nine months had elapsed with no evidence of further recovery. Records were kept of the degree of recovery, measured periodically according to the standard of the Harvard Infantile Paralysis Commission. In many cases, more recovery was seen during the third year of recumbency than during the second year. The degree of muscle recovery was less during the winter than the summer months. If the factor of fatigue of recovering muscles was fully appreciated and prevented, it was worth while to continue recumbent treatment for longer than the two years which had usually been allowed.

CORRECTION

In the paper on Progressive Pseudohypertrophic Muscular Dystrophy by Dr. Garry DeN. Hough, Jr., published in *The Journal* for October 1931 (Vol. XIII, page 825), an error was made in the dosage of adrenalin. The sentence beginning at the bottom of page 835 should read: "Their method of treatment consisted of the subcutaneous injection of two-tenths to three-tenths cubic centimeters of *a one-tenth per cent. solution of adrenalin* and one-tenth to two-tenths cubic centimeters of a one per cent. solution of pilocarpin hydrochlorid, given daily or every second day up to fifty or sixty doses without interruption."

Current Literature

TUMORS OF BONE; WITH DIFFERENTIAL DIAGNOSIS OF BONE DISEASES. By Charles F. Geschickter, M.D., and Murray M. Copeland, M.D. New York City, The American Journal of Cancer, 1931.

To a book of this type it is hardly possible to give an adequate review, except to describe the scope of the subjects considered, the methods of treatment of its contents, and the information which it contains for which one may turn to its pages. Written by men of large experience, and with accumulated knowledge and material acquired by the cancer research at their disposal, the authors have brought this subject up to date, and there is given to the student of these conditions the information which he needs and which is at this time available.

There is a foreword by Dr. Dean Lewis, written from his large surgical experience. This is followed by a foreword by Dr. Joseph Bloodgood, to whom the book is dedicated, and who gives advice from his large experience on the modes of procedure, of examination, etc. These two forewords in themselves constitute a valuable part of the work, and contain in that introduction valuable suggestions and methods of procedure both in the study and treatment of these difficult conditions. The book takes into consideration practically all the varieties of bone tumors, discusses each as to its general characteristics, clinical, macroscopic and microscopic, pathological findings, and especially as applied to diagnosis, and also considers the forms of treatment to be advocated. The etiological factors, and especially the relation of the growth of these conditions to normal structures, are discussed in detail and with accuracy, and lead to the accepted and scientific study of this group of tumors.

The subject is considered, as is stated in the introduction of the book, with the attempt to keep definite the separate entities as being necessary for accuracy and for usefulness, and in each chapter the different types of neoplasm have been treated more or less completely, so that each may be consulted independently of the main theme. The subject is considered according to the method advocated by the Bone Registry of the American College of Surgeons, and the terminology recommended by them is used.

The book is divided into two parts,—I, the tumors related to osteogenesis, consisting of those (a) derived from precartilaginous connective tissue, and (b) those related to subsequent cartilage growth; II, the tumors of known osseous origin.

The book is profusely illustrated, with roentgenograms excellently reproduced. Part III is a supplement in which is treated the subject of therapeutic measures of the lesions of bone, and also of differential diagnosis. The book should be studied by all medical men, for all practitioners at times must come into contact with the affections treated in this book.

TUBERCULOSE OSSEUSE ET OSTÉO-ARTICULAIRE. Parts I and II. By Dr. Etienne Sorrel and Mme. Sorre'-Dejerine. Paris, Masson et Cie., 1932. 380 francs.

In previous volumes of the series which have been published by Masson et Cie., the subject has been presented in a purely graphic manner, the large number of illustrations being used to describe the conditions with but very little text. In these two volumes, the subject is treated in a different manner. It is a full treatise which presents in detail the subject of tuberculosis of bones and joints, using a very large number of roentgenograms and photographs to illustrate the matter in the text. The basis of the material in these books is found in the lectures that Dr. Sorrel has been accustomed to give to students and to practitioners during his service in the Maritime Hospital at Berck. In these he has endeavored to present the result of his experience. He has emphasized the result of his experience rather than too much of the historical portion of the subject. This he has

been able to do since it was gained from his contact with a very arge amount of material in his large hospital.

Each group is considered separately and completely, so that it may be studied without reference to the general text. The subjects are all treated on a uniform plan, considering the etiology and frequency, the pathology (in which part the various forms met with are described), symptomatology, the diagnosis, and the treatment. The different methods of treatment are described and are illustrated by excellent drawings. The operative, as well as the conservative, methods are discussed and the text supplemented by excellent illustrations. The author leans at times toward the operative methods, especially with tuberculosis in some locations and in some types of this disease, and the technique or procedure is carefully described and illustrated by excellent diagrammatic and anatomical drawings, demonstrating the stages of the operation. Discussion of the indications for the choice of procedures, conservative and operative, is included.

The arrangement which is chosen for the presentation of this material makes it easy for the reader. The grouping used is: first, the tuberculosis of the long bones, the smaller—such as the metacarpal—with the various types of spina ventosa, followed by the description of this condition in the long bones. The shorter bones are then considered, lesions in the tarsus and carpus. The second main group includes tuberculosis of the joints, in the same manner treating first the smaller and proceeding gradually to the larger articulations,—such as the hip, the knee, and the spine.

These two volumes are a distinct addition to the series on this general subject which are now being published by Masson et Cie.

Die Gesunde und Kranke Wirbelsäule im Röntgenbild (The Normal and Pathological Spine in the Roentgenogram). By Geh. Med.-Rat Prof. Dr. Georg Schmorl and Dr. Med. Herbert Junghanns. Leipzig, Georg Thieme, 1932. 32.50 marks.

That this new work is flying the colors of an x-ray monograph as Supplement 43 of the *Fortschritte auf dem Gebiete der Röntgenstrahlen* is unfortunate. One might be led to think that it was limited to x-ray studies. One must read the subtitles to discover that Prof. Schmorl is a pathologist. It is really necessary to visit him in the laboratories in Dresden to appreciate the thoroughness of his work and the profusion of material which he has worked up. About 10,000 spines have been examined. After removal from the body they are bisected in the sagittal plane. One half is macerated and the other kept in preserving solution. X-ray, microscopic, and gross studies are made of these halves. Dr. Herbert Junghanns, himself the author of numerous articles on the spine, has collaborated in the preparation of the x-ray and other material.

A glance at the illustrations is sufficient to prove the value of presenting photographs of the preserved or dry skeleton, side by side with x-rays of the same material. In the latter, bone detail is beautifully projected because of the absence of soft-part shadows. The legends are complete in themselves, thereby furnishing an aid to rapid reading not always encountered in German books.

This monograph is more than a summary of the previous articles by Prof. Schmorl and his assistants. There has been considerable new material added to complete the discussion of the development, maldevelopment, and diseases of the spine, with appropriate emphasis on the intervertebral discs. Cartilage nodes have already been linked with Schmorl's name. His work on the development and degenerative changes in the vertebral epiphyses, marginal ridges, and ligaments, is even more important. The chapter on displacement, injury, disease, and degeneration of the vertebral discs is perhaps of greatest value.

Anomalies of the bodies and laminae are represented by numerous examples and diagrams, with especial emphasis on the lumbosacral region. Diseases of the spine lend themselves well to pictorial reproduction, and well selected case summaries lend vitality to the illustrations. A brief consideration of fractures serves at least to verify

the surprising frequency of multiple isolated and marginal lesions. The consideration of primary and secondary new growths is simple and brief. Spinal curvatures of all ages and causes are dealt with in a separate chapter. In elaboration of the original material it would be difficult to find a better summary of the literature of the subject in the brief space of two hundred pages.

A Text-Book of X-Ray Therapeutics. By Robert Knox, M.D., C.M. (Edin.). Completed and edited by Walter M. Levitt, M.B. (Irel.). New York, The Macmillan Company; London, A. & C. Black, Limited, 1932. $7.00.

This book was intended to be a new edition of a book published by Knox in 1923, but he died before it was completed. The book was completed by another radiologist with the result that it now represents the combined experiences of the two authors. It is a real *textbook* of x-ray therapeutics, treated in all its phases. The arrangement of the text is logical,—the first subject considered is the effect of x-rays on tissues; then, the physics of x-ray therapy, with several chapters on measurements of x-rays, the different filters used, and the various types of machines used in therapy.

Treatment of pathological conditions is discussed by body systems. A brief statement is made as to the possibilities of treatment of lesions of the various organs,—whether results warrant it, and the technique of treatment. Very reasonable claims are made for this type of therapy and frank statements are made when the writer believes other methods of treatment offer more hope of cure.

The most detailed chapters are those dealing with the technique of therapy and it is in this field that the writers put forth certain new ideas in therapy. This section and many of the others are very well illustrated.

Die Technik der Knochenbruchbehandlung. By Dr. Lorenz Böhler. Vienna, Wilhelm Maudrich, 1932.

The third edition of Prof. Böhler's work on fractures will be welcomed. The previous edition was reviewed in *The Journal of Bone and Joint Surgery* (XI, 885, October, 1929). This edition is enlarged, both in text and in illustration, and the author has added the results of further study of the normal and pathological anatomy, which he has applied to the methods of procedure which he has developed and has put into use in his clinic. He has also added to the chapters on the consideration of dislocations and joint inflammation and infections of the hand, which conditions are met with so frequently in his special work.

The book is a comprehensive one, including the treatment of practically all of the types of this group of injuries which come into the field of traumatic surgery. It is copiously illustrated with photographs of the types of injuries and of the various methods used in their treatment. Particularly does the book abound in the practical application and practical suggestions which are valuable not only to the surgeon who has had a large experience in the treatment of fractures and all traumatic injuries, but especially to those who are not so familiar with the treatment of these cases.

The book is a very distinct addition to the literature of this Department of Surgery.

The Technique of the Non-Padded Plaster Cast. By Fritz Schnek, M.D. Translated by Douglas D. Toffelmier, M.D. Vienna, Wilhelm Maudrich, 1932. $5.00.

In the large clinic of Prof. Böhler, in which a very great number of fractures are treated, retention by the plaster-bandage splint has been found to be the most effective. The immobilization of fractures after reduction—especially of the fractures with infected wounds—is essential and the most effective method is always sought for. The unpadded cast has been found preferable in their hands. The author discusses the essential features of both the padded and the unpadded methods of the use of plaster and meets very

clearly the objections usually raised to the unpadded plaster-of-Paris cast by the description of the technique for its application and also by the results obtained by it. He shows also the objections to the padded cast and the unfortunate results often following its use. He clearly demonstrates the advantages of his method, and, as in all surgical procedures, familiarity with the technique and professional skill are essential. Realizing this, the author has given detailed and accurate explanations for the use of this method, including the making of the plaster-of-Paris bandage itself, and the making of the plaster-of-Paris splint, with its application to the part. He also discusses the points necessary for the care of the plaster and the observation of the patient, the method of removal, and its preparation for its reapplication as a removable splint. He emphasizes the care necessary in the position of the limb, not only in the application of the plaster, but also in the position of the patient in the after-treatment. With the same thoroughness of detail, the author considers the application of the general principles of technique to the various fractures in the different parts of the body, the position of the limb, and the special application of the splint to the various fractures.

The book is profusely illustrated. Of special value are the illustrations of casts which are incorrectly applied and the demonstration of faults to be particularly avoided. This work will be found most suggestive and helpful to anyone who wishes instruction in the skilful use of plaster as a means of immobilization.

Rheumatic Infection in Childhood. By Leonard Findlay, M.D., D.Sc., M.R.C.P. New York, William Wood & Company, 1932.

The etiological significance of acute articular infections to all types of arthritis has been so frequently questioned that there is found in this study of 701 cases of acute articular rheumatism by Findlay an extremely suggestive commentary. The material at his disposal has been very carefully worked up and the author's wide experience has enabled him to handle it in a very conclusive fashion. The modern view appears to be that it is a chronic disease with a decided tendency to acute exacerbation. The very great frequency with which it plays a rôle in the causation of heart lesions, its relations to chorea, and its tendency to manifest a selective affinity for certain fibrous (rheumatic nodules) serous tissues of the body are well brought out. The historical development of its lesions from Baillou's first description in the sixteenth century down to and through the time that auscultation (1816) came into use, as well as the later developments, are interestingly cited. Morbidity and mortality statistics, and the relation of sex, age, and environment to incidence, are based upon recent and comprehensive surveys made abroad and in this country. Failure to positively identify a constant, causative bacteriological factor by the numerous observers who have made such claims does not, in the author's view, prove that it is not a disease of bacteriological origin, but leads him to incline to the parasitic theory, principally for the reason that its response to specific treatment puts it in the class with syphilis and known spirochaetal diseases manifesting such behavior to certain specific drugs. It may be that there is a non-filterable organism that is responsible. Scarlet fever, tuberculous polyarthritis, and syphilis may give rise to some confusion in diagnosis. The arthritic manifestations of rheumatism are its most characteristic phenomena. The joint effusions, whether they be serous or purulent, have an abundance of cellular elements, polymorphonuclear in character, but on examination by cultural or staining methods do not contain organisms. Onset is usually rapid, distribution multiple, but there is a tendency to skip from joint to joint and less acid perspiration is noted than in the adult. Of the 701 cases forming the basis of this study, 322 had arthritic lesions, and of this number 72 per cent. showed cardiac damage. One hundred and eighty children had chorea as well as arthritis, and of this number seventy-one per cent. had cardiac lesions. Endocarditis, myocarditis, pericarditis, chorea, skin rashes, and rheumatic nodules occur in varying frequency in the articular rheumatism of childhood. He discusses the relation of tonsillar inflammation to the incidence of the disease and in his personal experience found it present in only four per cent. of his own

cases. The author has seen very few rheumatoid joints in childhood and only rarely were they confusing as to diagnosis. The last two chapters in the book, on prognosis and treatment, are equal in importance and in the clarity of their discussion to the earlier portion of the volume, and enable one to close the book with the feeling that a valuable review of the present-day knowledge of the significance of articular rheumatism in childhood has been completed.

HANDBUCH DER GESAMTEN UNFALLHEILKUNDE. By Geh. Rat. Prof. Dr. Fritz König und Prof. Dr. Georg Magnus. Stuttgart, Ferdinand Enke, 1932.

This work consists of four volumes, and is intended to include descriptions of all the various forms of industrial disease.

Volume I contains chapters on the history of industrial laws of Germany. There is further a statistical analysis of cases treated under the present insurance laws, over a period of years.

Under the heading of traumata are found discussions of mechanical, electrical, and thermal injuries. These subjects are treated in a general way, by enumerating the different types of injury, methods of production and brief outline of treatment. The authors call attention to important points which may be overlooked and to possibilities of complications. The chapter on electrical injuries is supplemented by a thorough review of the fundamental principles involved in electricity, and illustrations, by word and diagram, of the methods by which these injuries may be produced, and how avoided. Thermal injuries include burns and freezing.

In wound infections, emphasis is placed on the importance of prophylaxis, and on the education of the laity in the early care of wounds.

Among the diseases of bones and joints which receive attention are osteomyelitis and surgical tuberculosis. In both of these conditions, the author presents evidence to show that trauma is very seldom, if ever, an indisputable factor in causing the infection. In an interesting, clear-cut and convincing manner, Lubarsch informs the reader that tumors are not traceable to traumata incident to industry.

One chapter is devoted to a consideration of metabolic diseases, in their relation to trauma, another to acute poisoning by various agents.

As a matter of being as complete as possible, the authors have included a philosophical discussion, by a legal expert, of the relation of injury to disease, the civil rights of the disabled and the technicalities of law, encountered in industrial insurance. The important subject of traumatic neuroses is discussed at considerable length from the medical standpoint, portraying the attitude of the disabled laborer and also that of the attending surgeon.

The material in this volume is presented in a general manner, without any lengthy discourses on etiology, pathology, and treatment. The authors adhere very closely to their purpose of considering industrial diseases, in their relation to industrial traumata.

TECHNIQUE DE L'OSTÉO-SYNTHÈSE. ÉTUDE DE QUELQUES PROCÉDÉS. By Robert Danis. Paris, Masson et Cie., 1932. 55 francs.

It is an unusual satisfaction to receive a work devoted to the full consideration of the technique of various surgical procedures which are recognized by experience as applicable to the treatment of a surgical problem. In this book the author has taken the various operative methods used in the treatment of fractures and discussed the principles involved in them and the indications for their use. Although he is much in favor of the method of suture by a special technique of wiring, he gives each one generous attention and emphasizes the necessity of sufficient equipment for this special surgery, and includes a description of a specially constructed table applicable to the different anatomical parts, and also describes the special instruments used in these surgical procedures. For wiring, he prefers a non-oxidizable steel wire, and uses it for the suturing of the adjoining edges of

the fragments, not wiring by the circular method. He rightly raises a protest against the method of tight circular pressure as introducing the danger of interference with full nutrition. The author then devotes a chapter to the methods of fixation, and emphasizes the necessity of care in securing fixation. He prefers a metallic mesh, reinforced by strings of non-oxidized steel wire, which is molded to the limb and the meshes then filled with a celluloid solution. The apparatus is light and strong and, by the insertion of lacings, can be used as a removable splint. In the last portion, he discusses rather critically the use of plaster, and gives his reasons for his objections. The last portion of the book is devoted to the discussion of the technique in the various fractures in which the wire suture is used, and is illustrated by cases with their results. In the several pages of introduction the author gives in a somewhat aphoristic way advice and directions illustrative of the methods of treatment which he has formulated from his personal experience.

VERHANDLUNGEN DER DEUTSCHEN ORTHOPÄDISCHEN GESELLSCHAFT, SECHSUNDZWANZIGSTER KONGRESS, SEPTEMBER 14 TO 16, 1931. Beilageheft der Zeitschrift für Orthopädische Chirurgie, Vol. LV, 1932. Stuttgart, Ferdinand Enke. 30 marks.

A few evenings with the *Verhandlungen* is the best substitute available to many for actual attendance at the annual meeting of the German Orthopaedic Association. Carefully edited papers and accurately transcribed discussions of the three-day session are collected in a single volume of 432 pages. The meeting of 1931 under the presidency of Prof. Wollenberg was reported in *The Journal* of January 1932. Under the editorship of Prof. Hohmann the publication has lost none of the vitality of the first presentation.

From the opening address of the president to the last case presentation, the material is of unusual interest. Half-day symposia on the relationship of heredity to orthopaedics, spastic paralysis, and the operative treatment of flat-foot are generously supplemented by papers on varied subjects. The injection of joints with radio-opaque dye, the experimental and theoretical consideration of arthritis deformans, pathological changes of the intervertebral discs, the etiology and significance of Stieda's shadow, and the origin of congenital dislocation of the hip suggest only a few of the problems discussed.

As an easily accessible cross-section of the opinions and recent developments of German orthopaedic surgery, the *Verhandlungen* maintain their usual excellence.

PLASTIC SURGERY OF THE NOSE, EAR AND FACE. By Victor Frühwald, M.D. Vienna, Wilhelm Maudrich, 1932. $4.00.

It was not the intention of the author to present in this small volume a complete textbook of plastic surgery. It was rather to put into print certain basic points from his long experience as a teacher of plastic surgery.

Certain of the more important operations for correction of deformities of the nose, ear, and face are described and illustrated by schematic drawings in two colors. He does not illustrate by photographs taken before and after operation, as he thinks the teaching of principles is of the most importance.

The book is an excellent one for beginners in plastic surgery and also of value for men of more experience. The final chapter would be of help to the surgeon who believes that face lifting and other forms of beauty surgery are worth while.

HANDBUCH DER UNFALLMEDIZIN, ERSTER BAND. (Handbook of Accident Medicine, First Volume.) By Dr. Constantin Kaufmann. Stuttgart, Ferdinand Enke, 1932. 55 marks.

The fifth edition of the first volume of this comprehensive two-volume work has been rewritten to conform to present status of insurance and legal medicine in Germany, Austria, and Switzerland. An opportunity has been afforded the writer to enlarge on

the clinical material and to include excerpts from the more valuable recent contributions to the medical literature. The first volume comprises a three-hundred-page analysis of the general problems of health insurance and industrial medicine, and five hundred pages of detailed case summaries and clinical discussions of accidental injuries. The topographical arrangement facilitates reference to specific regions as the detailed index adds to ease of finding the discussions of the typical and rare traumatic lesions. Characteristic of the entire presentation of material is the correlation of the problems of the local clinician with those of expert examiner and insurance adjuster. Official decisions which have established precedent are given in abstract with references to the original sources. As a guide to the estimation of disability, the handbook should be valuable to the industrial surgeon and to all who are involved in care of accident cases.

PAPERS ON SURGERY AND OTHER SUBJECTS. By George Tully Vaughan, M.D., LL.D., F.A.C.S. Washington, D. C., W. F. Roberts Company, 1932.

The taste which must be catered to in the book-reading public is varied and this is true in respect to medical publications as well as to general literature. Formal compilations of the facts of importance in diagnosis and treatment are essential, in the shape of textbooks. Scientific monographs, adding to the sum of knowledge within a narrow field, are of the greatest importance. Historical and biographical contributions, bringing out the trends of thought and the lives of those who have played significant rôles in advancing the profession, are becoming more widely sought, and, finally, the setting forth of the experiences of those whose clinical opportunities for study have been extensive often contains material that is interesting and valuable. To this latter class belongs this volume of Dr. Vaughan's. The subjects treated cover a wide range of general surgery varying in importance from transplantation of a knee joint to circumcision. Interspersed are numerous papers on general subjects,—from the Execution of Edith Cavell, given as an address before a graduating class in a nurses' training school, and Bullfights in Vera Cruz to Companionate Marriage. The contents of the book is the passing in review of the materials out of which has been evolved a successful career. Such an account has its interest and its value.

DAS MÜNCHENER SONDERTURNEN UND ANDERE WEGE ZUR KÖRPERLICHEN ERTÜCHTIGUNG. Edited by Geh. Hofrat Prof. Fritz Lange. Munich, J. F. Lehmann.

In this small volume, written by himself and several of his confrères, Dr. Fritz Lange has presented most practical information for the gymnastic teacher and the physiotherapist, as well as the practising physician, on those physical conditions and defects which can be treated by physical exercise and the simpler hygienic measures. Many of the postural and stature defects are described and their development explained. Considerable space is devoted to the subject of nourishment and hygienic measures. The correction and treatment by exercises is given in detail and illustrated by many photographs. The book is devoted to a field not usually covered, and is presented in a way which makes it available to those who should find it of use in their daily work.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Annaes Paulistas de Medicine e Cirurgia. S. Paulo, Brazil, Vol. XXIII, Nos. 1, 2, 3, and 4, January, February, March, and April 1932.

Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCIII, Nos. 4, 5, and 6, April, May, and June 1932.

Kirurgiske Pankreassykdommer og Postoperative Pankreaskomplikasjoner. Kliniske Studier. By Olav Usland. Tilleggshefte til Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCIII, No. 4, April 1932.

Høifjells-Sanatoriet i Gausdal. Prospektus for 1932 samt Laegeberetning for Sesongen 1931. Bilag til Norsk Magasin for Laegevidenskapen, Vol. XCIII, No. 4, April 1932.

Anales del Instituto de Biologia. Mexico, Vol. II, No. 2, 1931.

Ortopedia e Traumatologia dell' Apparato Motore. Rome, Vol. IV, Fasc. 2 and 3, April and May 1932.

Journal de Médecine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CIX, No. 7, March 10, 1932.

Bulletin of the National Tuberculosis Association. Vol. XVIII, Nos. 5 and 6, May and June 1932.

The Johns Hopkins University Circular. School of Hygiene and Public Health. Catalogue and Announcements for 1932–33. Baltimore, No. 436, April 1932.

A Second Study of the Prevalence of Syphilis and Gonorrhea in Upstate New York. By Albert Pfeiffer, M.D. and Herbert W. Cummings. Albany, New York State Department of Health, 1932.

The Responsibilities and Opportunities of the Social Worker in the Field of Social Hygiene. By Herbert W. Cummings. Albany, Division of Social Hygiene, New York State Department of Health, 1932.

Doppelseitiger Mb. Kienboeck bei 2 Brüdern (Bilateral Kienböck's Disease in Two Brothers). Axel Ringsted. *Acta Chir. Scandinavica*, LXIX, 185, 1932.

The fact that changes of the os lunatum characteristic of Kienböck's disease may be demonstrated by x-ray in the absence of definite clinical findings and symptoms is substantiated by one of the cases reported. With two bilateral out of a series of fourteen cases, there is a definite suggestion of symmetry of the lesion. While the etiology is obscure, trauma is unlikely as a primary cause and constitutional factors are of some importance. The two cases are reported in detail.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

An Osteogenic Sarcoma of a Dog: Pathologic and Roentgenologic Observations. W. H. Feldman and F. A. Ford, *Am. J. Cancer*, XVI, 377, 1932.

The authors describe a tumor of the left ulna of an English setter, and present roentgenograms and histological studies on the basis of which the tumor was diagnosed as an osteogenic sarcoma. The tumor established pulmonary metastasis and progressed to a fatal termination in spite of amputation and x-ray treatment in massive dosage. Reports of similar tumors occurring in other animals are briefly reviewed.—*G. W. Taylor, M.D., Boston, Massachusetts.*

Undifferentiated Round-Cell Sarcoma of the Ilium (Ewing Tumor) Containing Hemopoietic Elements. N. W. Roome and P. A. Delaney. *Am. J. Cancer*, XVI, 386, 1932.

The authors report a case of a large primary tumor of the ilium in a young man, with widespread skeletal metastases. The article is well illustrated with roentgenograms and photomicrographs. Special staining methods demonstrated the presence of differentiated cells of the hemopoietic series as well as undifferentiated hemocytoblasts. On the basis of these findings they class the tumor as a Ewing sarcoma, possibly merging into a hemocytoblastoma.—*G. W. Taylor, M.D., Boston, Massachusetts.*

Nouvelle Technique de l'Arthrorise Tibio-Tarsienne Antérieure par Lambeau Astragalien Pédiculé. (New Technique for Anterior Bone Block of the Ankle by Pedicle Graft from the Astragalus.) L. Michel. *Rev. d'Orthop.*, XIX, 54, 1932.

The author finds that the original operation of Putti, in which the tibial graft is inserted into the astragalus at the anterior margin of the ankle joint in order to block dorsiflexion, is unsatisfactory because the graft breaks. In Putti's recent operation, a

pedicle graft from the neck of the astragalus is turned up from below upward and bone chips are packed in behind it. Apparently this is a satisfactory operation, but the author reverses the direction of the pedicle,—that is, with the foot held in a position of equinus, the anterior portion of the astragalus is exposed and, beginning at the articular surface, a pedicle graft is elevated with its base downward. Then the foot is immobilized in a position of slight equinus. The operation should always be accompanied by subastragaloid and occasionally by midtarsal arthrodesis.—*J. Albert Key, M.D., St. Louis, Missouri.*

ARTHRODESIS OF HIP, WITH SPECIAL REFERENCE TO METHOD OF SECURING ANKYLOSES IN MASSIVE DESTRUCTION OF JOINT. L. C. Abbott and F. J. Fischer. *Surg. Gynec. Obstet.*, LII, 863, 1931.

The authors describe a method of hip arthrodesis designed for hip joints with extensive destruction due to pyogenic or tuberculous infections. Correction of the deformity is the first stage and is brought about by simple adhesive traction, or, if necessary, by skeletal traction following an operation designed to free the trochanter from the ilium.

After the extremity has been brought into wide abduction, so that the greater trochanter approximates the acetabulum, the patient is ready for the second stage,—the arthrodesing operation. Through a Smith-Petersen incision, cortical bone is bared in the upper and inner aspects of the acetabulum and on the superior, anterior, lateral, and posterior aspects of the upper end of the femur. Broad contact of cancellous bone to cancellous bone is brought about by widely abducting the leg, and placing the upper end of the femur into the acetabular bed. At this time the main point is to gain accurate contact by as much abduction as is necessary, and the line of weight-bearing is ignored. A double spica cast secures the fixation.

The third stage consists of a subtrochanteric osteotomy, followed after several weeks by gradual bending of the callus until that position of the hip is secured which permits the best possible function of the extremity. The callus is usually perceptible by means of the x-ray two weeks after the osteotomy, and bending of the callus by traction usually consumes about ten days. The desired position is maintained by traction and is carefully and repeatedly checked. It is believed that this careful checking and gradual correction brings about a more perfect functional position than can be gained by operative correction and plaster fixation in one stage.

Eleven cases are reported; disease was quiescent in nine. In one of these cases, ankylosis had not taken place in one year. Sinuses were present in two of the cases,—in one, ankylosis and healing had taken place in fourteen months; while, in the other, ankylosis and healing was not present eleven months after operation. The results were highly satisfactory in all but the two cases.—*Hugh Jones, M.D., Los Angeles, California.*

FRACTURES OF THE METATARSAL BONES DURING MARCHES. H. Turner. *Voyenno-Med. J.*, II, 188, 1931.

The author presents a detailed review of functional disorders of the foot. A great number of authorities are cited on the subject of the so called march fractures of the foot. This affliction usually appears in young soldiers after a prolonged march; it is manifested by pain and swelling of the dorsum of the foot. The x-ray study shows a slow-growing thickening of the periosteum of the metatarsals, osteoporotic changes, and subsequent solution of continuity simulating fractures. The author had an opportunity to remove fragments of such a metatarsal for study. He came to the conclusion that the affliction is a neurotrophic disease of the bones of the foot produced by functional injury to the terminal branches of the deep peroneal nerve, causing secondary pathological changes in the metatarsals with possible late linear fractures.—*Emanuel Kaplan, M.D., New York City.*